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AN INTERACTIVE COMPUTER MODEL TO ANALYZE THE SEATOUR OPPORTUNITIES OF THE SUBMARINE OFFICER CORPS

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

AN INTERACTIVE COMPUTER MODEL
TO ANALYZE THE SEATOUR OPPORTUNITIES
OF THE SUBMARINE OFFICER CORPS

by

John Frederick Teply

March 1980

Thesis Advisor Paul R. Milch

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An Interactive Computer Model to Analyze the Seatour Opportunities of the Submarine Officer Corps

by

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Lieutenant, United States Navy
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March 1980

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PREFACE

The SUBTOURS interactive computer model was constructed in the APL computer language (Ref. 3) on the IBM 360 computer of the Naval Postgraduate School. This work was part of the Research in Officer Manpower and Personnel Planning sponsored by the Principal Deputy Assistant Secretary of the Navy (Manpower and Reserve Affairs) and the Deputy Chief of Naval Operations (Manpower, Personnel and Training, OP-01). For that reason the model is now also available on the APL * PLUS system of the Scientific Time Sharing Corporation and is accessible by the manpower managers of OP-01.

A potential user of the model could quickly familiarize himself with the model by reading Sections III.B.2.a and b, Sections IV.B.1 and 2, and accompanying Appendices.

I. INTRODUCTION

Manpower resources are gaining ever increasing attention in the environment of the all volunteer armed forces. The acquisition of talented and qualified individuals is as much or more of a challenge to the Navy than procuring its hardware. In light of this challenge it is more than ever before expedient to plan the distribution of this resource in an increasingly intelligent manner (Ref. 2:269).

To properly plan for effective manpower distribution in an environment as dynamic as the defense community requires the collection, organization, and analysis of a diverse and voluminous amount of information in a short period of time. When policies change with regards to manpower, because of changing attitudes within and without the military, the manpower manager must be able to adapt his plans to the change, since decisions made in the present will no doubt have an impact on the career patterns of officers in the future. Thus, any means whereby the receiving and processing of this information can be automated will greatly assist the manager in sorting and analyzing alternatives to distribution and may very well end in some cost savings as a result of effective planning.

The purpose of this thesis is to introduce an interactive computer model that was designed to assist the manpower manager in the planning of personnel distribution and development of an effective professional development path. The model

was designed for use with the submarine officer corps, both nuclear and strategic weapons systems (SWS) officers, and was tested with realistic data from the submarine community. (Refs. 6 through 12 and 16) The unclassified information was analyzed using various alternatives to the present manpower allocation to sea duty for both the nuclear trained and strategic weapons systems officer. No classified information was consulted so that the model would receive wider exposure and could be more readily accessed.

The model uses four inputs to determine the opportunities for an officer to obtain a seatour position or the shortfall of seatour positions to be fully manned. The first two inputs, the number of ships in the future that must be manned and the number of billets per ship for each tour position, determine the requirements that must be met for positions at sea. Tour positions (the years of service necessary to be eligible to fill a billet and length of the tour in that billet) and the stock of officers in the future by year group and rank are the remaining two inputs. These two sets of information, when combined, result in the number of officers available to fill the required billets. For each tour position, over future years, requirements are compared to availabilities which yield the ratio of seatour opportunities.

The significance of the model lies in its ability to change input information (temporarily or permanently). This permits the user to analyze various alternative allocation policies. For example, he/she may wish to see the effect

that lengthening the division officer's tour has on meeting the present requirements. Also, he/she may wish to investigate the implications on officer supply if more ships of a certain type will be authorized for delivery sooner than presently planned. With the ability to experiment on a computer model the analyst can instantly detect trends which may require changes to the present allocation policy.

The exact numerical value of seatour opportunities is significant only when compared with the protracted results of other fiscal years or in relationship to other tours. The ratio is a way of visualizing the result of manpower to hardware resource allocation and the degree to which manipulations to the present policy plans can effect that result. This type of analysis is possible with an interactive computer routine which provides the user with an instant display of results so that a common line of analysis can be pursued without interruptions to his/her line of thought between iterations.

Though designed with the Submarine Officer Corps in mind, this model is equally adaptable to other naval communities and is in fact being developed for both surface and aviation forces by other researchers (Ref. 4 and 5). The submarine community offered a logical development path with which to test the first realistic data. The professional development of both nuclear and SWS officers is limited in variety because of the size and make up of the community and as such was easily adapted to a theoretical model. However, no naval warfare specialty has a completely uniformed career path.

The implications of this fact and ways to solve the obvious deviations from a uniformed career path are addressed in the section on extensions to the model in this thesis.

A typical computer terminal session is presented in Appendix D to illustrate a sample of the type of analytical gaming that can be performed with the model, and the results are analyzed in Section IV.B. for explanation of what was performed.

The intent in development of this model was to provide another tool to assist the manpower manager in planning for inevitable policy changes that will impact on the distribution of manpower within the submarine force and the Navy as a whole. So armed, the manpower manager can anticipate how requirements will be met rather than react to the effects of change in policy as they are realized in the actual forces.

II. THE SUBMARINE OFFICER'S PROFESSIONAL DEVELOPMENT PATH

In the submarine warfare community, as in any naval warfare community, the professional development of its officer corps is essential to maintaining a force of officers technically knowledgeable and professionally competent to operate and maintain the ships of the fleet in an efficient and effective manner. That professional development must proceed in an orderly fashion to be effective is clearly stated on a personal level in the Unrestricted Line Officer Career Guidebook (Ref. 13:45).

> "The fundamental goal of the nuclear trained submarine officer is to develope the professional skills and operational background to command a nuclear submarine. The achievement of this goal is accomplished through a definite series of professional qualifications, advanced training and operational sea experience."

The determination of a career development path that will fulfill the requirements of developing competent officers is an extensive problem, but it is one that must be dealt with in an aggressive and increasingly efficient manner as the requirements placed on the expertise of the submarine officer community grow.

The challenge to the manpower/personnel manager is twofold. On the one hand each individual officer must be channelled to an assignment that will best utilize his time investment to gain experience and practical or formal training. In this way the potential for achievement can be realized on an

individual basis, and on a larger scale the stock of officers that are adequately trained will meet the requirements for positions. On the other hand, the manager must plan assignments to meet the immediate needs of positions at sea and ashore that must be manned with available manpower, and he/she must anticipate the future requirements that must be met with accessions as requirements for positions change with changing hardware.

In meeting this challenge the manpower manager must use all the tools available to him/her to analyze the effects of various decisions, in order to plan more effectively and establish the correct priorities that efficiently man sea and shore positions.

The professional development path is necessary to bring structure to the problem of assignment of personnel. Though it may not be rigid in its requirements for every step, it will aid in focusing the solution to assignments on a macroscopic level.

The present career paths of both nuclear and SWS officers are contained in Appendices B and C and are extracted from the Unrestricted Line Officer Career Guidebook (Ref. 13). Each career path has many parameters affecting it. The explicit parameters are the placement, length, and number of tours. Some constraints not explicitly obvious are requirements for formal training, rank specifications that are implied or documented, dependency between tours, and the necessity for a certain order in which the tours appear.

Some of the requirements are peculiar to the submarine community such as the type and length of initial formal training. However, many of the constraints are shared by the other naval warfare communities. This thesis explores the particular constraints on the submarine officer corps, but many of the general ideas of the career development path are being carried on in further studies such as Ref. 4, and others cited there.

When the constraints on the professional development path are recognized the next step is to search for those parameters that are amenable to adjustment, and to analyze the effects of such adjustments on meeting the requirements of the individual officer's career and the manning needs of the Navy as outlined above. To solve the distribution and assignment problem the manpower manager must use the structure of the professional development path as a model of personnel flows within his system, which is to say his warfare specialty.

Caution must be taken when manipulating the parameters of this model. Some of the parameters are interrelated in position or time. For example, lowering the number of positions in the department head tour may necessitate the transfer of some of these positions to the division officer level. This is a position dependent parameter. If a change in accessions is planned in the near future, as another example, it must be realized that the effects of this decision are felt much later in the senior ranks due to the closed nature of the Navy personnel system. This is a time dependent parameter.

In the submarine force in particular, the supply of officers is delayed from operational assignments for six months to a year and a half by required formal training. This factor limits the flexibility with which early tour positions can be moved around. Once on board the officers are assigned to various positions that could lead to increased flexibility of assignment. This is because the billet structure is not as rigid as in later tours. Both number of billets and tour length can be changed to make more or fewer positions required to be filled by the available officers.

It is incorrect to think that an individual officer must or will follow a standard path through its entirety. Conditions and requirements change over time. On a larger scale, though, the management of a system of manpower must be planned to ensure that requirements are being met, and if they are not being met to investigate why not. As the stock of officers available increases it is evident that the flexibility with which the manpower manager can manipulate a career path also increases. However, proper management of the parameters becomes especially critical in an era of declining input.

For this reason this thesis is written with the purpose of presenting some tools that the manpower manager can use in effective planning by analyzing various potential decisions, such as increased hardware appropriations or requirements for a new position aboard a new class of ship, for their effects on the professional development path. The means of analysis and some examples of analysis on hypothetical decisions are discussed in Section IV.

III. THE SUBTOURS MODEL

A. MATHEMATICAL FORMULATION

A mathematical model gives structure to a set of data that arise from a problem when that problem is translated into mathematical form. The model can then be used to assist in solving that problem. The SUBTOURS model is designed to structure the parameters that affect manpower assignment in the submarine officer corps. It matches officer requirements for positions at sea with supply of manpower, and it determines the ratio of demand vs. supply from which we can determine the specific parameters that cause a tour position to be under- or overmanned. The model analyzes positions on board ship over time from a start year in annual intervals for as many years as the data permits.

To determine officer requirements the number of ships per ship type per year is multiplied by the number of positions per ship type per tour. More specifically let

$$p_{ky} = \text{number of ships of type k in year y.}$$

Then P is a matrix of all p_{ky}'s and has dimension K x Y, where K is the number of ship types and Y is the total number of years for which we are analyzing. Further let

$$b_{kj} = \text{number of billets for ship type k in tour j.}$$

Then B is the matrix of all b_{kj}'s and has dimension K x J, where J is the total number of tour positions and K is as described above.

Requirements are determined by the matrix product:

$$R = B' \times P$$

where an element of the matrix R, r_{jy} is the requirement for officers in tour j during year y and B' is the transpose of B. Each tour requirement is the demand for a certain number of officers with a particular rank and years of service.

The officer supply is the number of officers available during a given year with the necessary years of service to fill a particular billet (seatour) type. These stocks are made available from another activity's model named POPI (Ref. 13) which predicts future officer supplies from historical data, continuation rates, and other pertinent information related to personnel movement in the Navy officer manpower system. For a given fiscal year the stocks of officers for each rank (Ensign through Captain) is given by POPI according to years of service. This information is restructured in the model to obtain a matrix of stocks by seatours and years. Here $S_{ng}(y)$ is the stock of officers of grade g with n years of service in fiscal year y. Let

$$S(y) = \text{the matrix of } s_{ng}(y)\text{'s with dimension } N \times G,$$

where N is the maximum years of service and G is the highest grade considered.

Since it is desirable to have only those officers with a particular seniority in service fill a given billet at sea, a matrix is formed of the percentage of time that a tour position is found in a particular year of service. Let

t_{nj} = the fraction of time spent in tour position j

by an officer with n years of service. Then T, the matrix of t_{nj}'s has dimensions N x J. For example, if tour position 3 encompasses all of the tenth year of service, then $t_{10,3} = 1$. If tour position 3 begins half way through the tenth year of service, then $t_{10,3} = 0.5$. If personnel with ten years of service do not serve in tour position 3 then $t_{10,3} = 0$.

Let

$$S^{*}(y) = T'S(y) \text{ and } T' \text{ is T transpose.}$$

The elements of $S^{*}(y)$ are $s^{*}_{jg}(y)$ and are equal to the number of officers of grade g available to serve in tour j during year y. Let

m_j = the minimum grade required for tour j (e.g., $m_3=4$ means that the minimum grade in tour 3 is grade 4 or LCDR). Then

$$s_j^{**}(y) = \sum_{g=m_j}^{G} s^{*}_{jg}(y)$$

= number of officers available for tour j in year y.

S^{**} is the matrix of $s_j^{**}(y)$'s dimensioned J x Y.

Finally, to compute the ratio of supply and demand each element or R is divided by corresponding element of S**. Since R and S** are both dimensioned J x Y the result is a matrix D of dimension J x Y where each element is the ratio of demand vs. supply. Then d_{jy} is the ratio of demand and supply for tour j in year y. Each element of D that is less than one indicates that supply exceeds demand, and its value is the chance an officer with the required years of service and grade has of obtaining a specific seatour billet in a certain year. Each element greater than one indicates that a billet may go unfilled or that adjustments must be made to fill it. Of course, an element of D equal to one means that supply matches demand exactly.

B. COMPUTER PROGRAM

1. Flow Diagram and Data Manipulation

The challenge of a computer programmed model is in simplicity of design to limit the complications of operation to the end-user and still retain the rigor of the mathematical model so that the results will be meaningful and as accurate as the assumptions allow. Accuracy of computation is assured with seventeen significant figures in modern computer equipment, but the manipulation and organization of data is left to the designer. A properly organized program allows access to any part of the data involved in computation, but does not allow false data to undermine correct operation of the program, and it alerts the user to any inconsistencies in the input. While it has been attempted in this model to exhaust

all possibilities of input error that would lead to inaccurate results, it is entirely possible that there still remains some combination of input that would cause the program to default.

The SUBTOURS program is designed for interactive use by employing the APL programming language (Ref. 3). Its main function is to calculate seatour opportunities (the ratio of requirements to inventories) from the data discussed in the mathematical formulation. However, its real usefulness comes from manipulation of the data used in the calculation of the ratio. As such, access to the displays and changes to any or all of this data are offered from any point in the program. The display feature is for instant updating on the status of information. Alterations can then be made in order to observe effects on the manpower requirements. However, either of these functions can take place first, and neither one need be utilized before the calculation.

Appendix A shows the flow diagram of the program. Though it may look unnecessarily crowded with flow paths, its function can be divided into the three parts of the program; display, change data, calculate. At each termination of data manipulation a decision is presented so that access to any other part of the program can be accomplished.

It is necessary in some alterations, such as adding tour positions, to lead the user directly to another change so it will not be forgotten. After all management of data is complete the program again resumes its capability of branching to any other function.

Finally, to preserve the global variables in which all the data are stored a provision is installed to allow the user to make the changes permanent or calculate the ratio from his/her temporary trial data. This provision is only offered after a change since it would be unnecessary if the program was used solely for calculation. The only change that is always permanent is a change in the supply matrix since it is stored in a global variable and not manipulated in the change program. One reason for this is that supply data are based on another predictive model (Ref. 14) and should be changed only on consultation with that model.

2. Program Construction

The SUBTOURS program is written in the APL language and was designed to allow the end user all options possible in analysis of career path data of his/her selection. At the same time the program checks input data and shapes it as necessary for logical inclusion into the calculations of sea-tour opportunities.

To achieve versatility the program uses several decision points allowing branching throughout the program to any of three major applications and several routines within those applications as the user desires. After completion of any task the program allows the user to again branch to any of the available functions including the same step just accomplished. The decision point approach rather than a step-by-step progression promotes time and space savings and helps the analyst keep his/her train of thought.

As changes are made in the data each piece of information is checked for compatability with the rest of the data. When scalar values are expected and a vector is entered the program automatically picks the first element, then checks to see if it is logical. Vector inputs are checked for proper length and logical values. Literal text is accepted only if it answers a question exactly.

The APL language allows active interaction with the user and versatility with banks of data such as vectors and matrices. The interactive feature gives instant display of output for a continuous flow of information between user and computer.

a. Functions and subfunctions

The main function or SUBTOURS function is involved in the general management of input data, calculations, and output format along with maintenance of each subprogram. The function loads in four sets of data that are more fully explained in Section II B2.b. Since the data are manipulated by matrix calculations data is checked to make sure rows and columns are compatible with each other and that there is enough information in each for complete analysis.

The function is started by specifying the calendar year in which the stored data begins and the number of years from the start year with which the user intends the model to deal. As an example, if the data stored cover fiscal years 1980-1986 and the user desires three years of seatour opportunities beginning with 1980 he would enter:

The entry on the left cannot exceed the total years of data stored in the ship projection or supply projection matrices. After the program prints a set of instructions (upon request) it prompts the user to select one of three applications of the program. The analyst responds by entering DISPLAY, CHANGE, or SEATOUR which will direct the program to the specified subfunction as shown in figure 1. A typical sequence of operations might be as follows:

1. Choose display of data to be analyzed for reference to the original data.
2. Request the change applicable to the data displayed and alter the data according to new constraints.
3. Return to display to check that change desired has been entered.
4. Select calculation function to display results of analysis.

The first subprogram is the DISPLAY function designed to retrieve and format data used in the calculations of seatour opportunities. It employs the library function FORMAT to shape output into an understandable form. Four sets of data may be displayed.

The first display is the number of ships projected for the future that will require manning. The ships are separated into ship types and ship types are named for easy

identification and numbered for facility of entry into other parts of the program.

Secondly, the tour positions are presented with start time and length. The start of a tour is the number of years of service an officer must have before he can fill the specified tour position. As an example, in Appendix B the department head tour starts at the completion of seven years of service. The tour length is three years. According to the model only officers with seven to ten years of service can fill a department head billet. Thus tour start for tour number two is seven, tour length is three.

It is also possible to display the billets necessary to man each ship type. The billets are presented corresponding to a ship type and a tour position. (e.g., Ship type A may have three billet requirements for tour position 3). A breakdown by ship type was chosen since that is the one area where billets most likely will differ. Two or more ship types may have the same number of billets in one tour position but may differ in another. For tour positions that do not apply to a certain ship type that ship type's billets will equal zero and will not affect calculations.

The fourth presentation is the matrix of officer stocks or supply that is projected for the future. Although the matrix is stored according to rank, as explained in Section II.B.2.b., the values are displayed, for the sake of brevity in total over all ranks, ensign through captain. The display is partitioned by years of service (YOS) and future fiscal years.

The second choice offered in SUBTOURS is the alteration of data by selecting CHANGE. The ALTER subfunction controls subordinate functions that rearrange data presented in the display function. Changes can be made to the ship projection, tour positions, and billet structure.

Simplest of the changes is a correction to ship projections in the SHPCHG function. Upon selection of the ship type new values for the number of ships projected in the future is inserted by row in the matrix of ships. When requested, the user must enter a value for all years presented even if some of the values remain the same.

Tour positions can be changed, new tours added and old tours deleted. If a tour position's values are changed the new values are inserted in the matrix in place of the original start and length. Since tours cannot overlap (because personnel cannot be in two places at once), if an erroneous value is entered, the program will automatically push later tours forward to accommodate the change, or update the new values to later start times if they overlap with an earlier tour. The user is warned of this condition and can correct it immediately by requesting TOURCHG for the faulty tour values. Tour positions cannot be assigned to cover a length of service for which there is no supply data. In this case the last tour of tours that exceed the maximum Y.O.S. represented by the data are truncated from the tour position matrix and billets are removed for the dropped tour. Again a warning is given to the user, and he has the option of

correcting the values in the new matrix and adding the truncated tour back into the matrix through the TOURADD function.

If additional tours are desired the TOURADD function makes space for them in the tour position and billet structure matrices. After expanding the tour position matrix the function immediately sends the user to the change tour function to insert the values for the new tours. The same precautions apply in changing tours as noted above. After entering new tour start and length times the function automatically sends the user into the billet change function to add billets for the new tours. If a new tour is truncated because it exceeds the maximum years of service of officer supply data, billets for new tours not truncated must still be entered. If more than one new tour is desired between two existing tours, all that is required of the user is to repeat the tour number in entry for as many tours as are desired. Given four tours, as an example, if it is desired to include two new tours after the existing tour two and one tour after the existing tour three the user would enter the vector 2 2 3 with spaces between the integers.

When a tour is no longer desired in the analysis the TOURDEL function removes the tour from the matrix and automatically eliminates any billets associated with that tour in the billet matrix.

The last two changes available are to the billet structure data. Depending on the type of analysis being performed the user can either change billets according to ship

type or tour position. The BILLCHS function inserts new billets for a specific ship type, i.e., across the columns of the matrix. The BILLCHT function provides new billets for a specific tour position. Entry of the change must again provide a number for each ship in the BILLCHT or each tour in BILLCHS even if some of the values remain the same.

Upon selection of the SEATOUR option the SUBTOURS function calculates seatour opportunities. As mentioned in Section II.A.2. the seatour opportunities are an array of ratios of demand vs. supply. They are associated with a tour position and fiscal year from the start year projected for as many years as requested. There are four steps in computing these figures. The matrices of SHIPS and the transpose of BILLETS are matrix multiplied together to obtain the number of positions required in each tour per fiscal year. The solution yields the requirements which form the numerator of the ratio.

The next two steps determine the number of officers available to fill the requirements. It has been mentioned that the model only accepts officers with the required years of service to fill a position. Another criterion is that the officers have a rank commensurate with the tour position or rank higher than required. Thus a lieutenant commander cannot fill a command position. To determine the first criterion the fractional matrix explained in Section II.A.2 is computed from the tour position matrix. For each tour position all years of service are given a percentage

multiplier between zero and one inclusive. When multiplied by the supply of officers the multiplier matrix will yield only the supply applicable to that tour. As an example, a department head tour may involve years of service between seven and ten. It may involve only half of year seven and all of years eight, nine, and ten. Then the matrix multiplier would be 0.5 for Y.O.S. seven, 1.0 for Y.O.S. eight, nine, and ten and 0.0 for all other Y.O.S. To determine the second criterion, ranks required for a tour position, the function INVENTORY finds the lowest rank associated with a tour by comparing it to the standard promotion schedule of Appendices B-1 and C, and then adding together all supply matrices of that rank and higher. To determine officers available each tour multiplier is applied to its corresponding supply from INVENTORY. The result is a matrix of officers available for each tour in the projected fiscal years.

Finally, in the fourth step each element of the requirements is divided by its corresponding element of the officers available to fill those requirements. As a precaution, any element of supply equal to zero is changed to one to avoid dividing by zero. A ratio less than one is the chance of any one of the available officers drawing a seatour billet, and a ratio greater than one is an indication that a tour is undermanned. A result greater than one is changed in the output format explained in the next section for a more meaningful interpretation.

b. Input and Output

To determine the opportunities for a sea tour there must be information available to the functions as described above. The data for the SUBTOURS program is stored in global variables, which are stored with their name and value along with the functions each time a workspace is saved. In APL a variable can have an entire array as its value which allows parallel computations within a function.

Within the workspace for the SUBTOURS program the projection of the number of ships per year is held in the variable SHIPS, tour position's years of service start and length in years is held in TOURS, the amount of billets per tour position for each ship type is held in BILLETS, and the officer stocks for future years is held in SUPPLY. The first three variables are two dimensional with dimensions as necessary to achieve compatibility in computations. The variable SUPPLY is three dimensional with each matrix of the array representing a specific rank. When the inventory of officers available for a tour is computed only those matrices (ranks) that are applicable are used.

If more than one set of data are being analyzed, as in the submarine officer corps with nuclear and SWS personnel, the different sets of data can be stored in another work space and copied onto the SUBTOURS work space. After copying the data both functions and variables can be stored again in the same place by issuing a save command. If a switch of data is desired copying the new work space of data will eliminate the old variables, and then the new data

can be saved as above. In this research the independent work spaces for nuclear and SWS personnel of the officer corps were named NUC and SWS respectively.

Once the data have been loaded along with the functions the global variables are duplicated into local variables immediately upon execution. Local variables, in APL, exist only during function run and as such will not disturb the global variables. Thus data can be manipulated and results analyzed without altering or losing the original information.

The library program FORMAT is part of the work space, formally saved along with functions and variables directly related to SUBTOURS. Its function is to shape the output into a neat report format for easier comprehension. The function of FORMAT performs several tasks to accomplish this. In addition to spacing and carriage functions it uses a global variable of the literal names of ship types for inclusion with the display and changes printed out for the user. It also allows insertion of literal text with numeric results for column headings and other data identifiers.

Throughout the program additional information is required from the user as to which options are desired. The function calls for two types of information at different times. If a question is asked that must be answered by a literal word or letter the terminal will merely stop printing and wait for a response. If numerical information is desired the terminal will prompt the user with a box character (window) followed

by a colon. If either type of question is answered with the incorrect type of character the terminal responds that there was wrong entry and inquires again for the correct information. The one exception to this rule, however, involves questions that require a yes or no response. Either YES or Y is accepted as a yes answer. All other characters are considered a no answer except for no response with a return of the carriage.

The output of seatour opportunities has one unique feature. If a value of the ratio is greater than one this indicates the tour position is undermanned. Rather than leave it a ratio of demand vs supply the value is inverted and added to minus one, the absolute value of which is the percentage the tour is undermanned. In the FORMAT program this negative value keys a step to put parentheses around the absolute value. Thus all output in the seatour opportunities matrix is between zero and one inclusive, and tours where manpower poses a problem are readily identified from positions where manpower is sufficient by the appearance of parentheses.

IV. APPLICATIONS AND ANALYSIS

A. MANPOWER MANAGEMENT APPLICATIONS

The manpower manager must use all the tools available to him/her to adequately plan for the optimal utilization of personnel under his cognizance. The operation of the SUB-TOURS model has been presented in Section III. It was designed primarily for use with the submarine officer corps but the applications of the model may be relevant for some other naval officer communities as well. To transfer the information of model operation from a theoretical point of view to practical applications it is necessary to explain how the program can be used in analysis of real data, and how it can be used in planning manpower decisions by experimenting with alternative policies.

One real advantage to planning by computer modeling is the savings in time and resources it offers by simulation of events as opposed to analysis by manipulation and observation over time of real resources. This second method is often costly in time, and in some cases cannot be performed for fear of upsetting the present status quo. A model also assures a higher reliability in the prediction of events than does direct extrapolation from previous documentation or experience, or simply planning by intuition of the expected results.

1. Billet Adjustments and Ship Requirements

Officer requirements are determined by the number of positions at sea that must be filled by qualified officers. A position is created to fulfill a requirement aboard ship, and the total number of positions required is simply the number of ships times the number of positions per ship. The billet requirements that are analyzed in Section IV.B. were determined from the various ship manning documents (Ref. 7 through 12). Each position is associated with a rank, a designation, and a navy officer billet code (NOBC). A review of the necessity to fill a position must consider both safe operation of the ship and the likelihood that the billet will provide the officer assigned to it the necessary training and experience to gain the skills for advanced development.

The first consideration must include a review of the ranks and NOBC's assigned to different jobs. If there is any flexibility without reduction in safety some billets could be moved to another tour or added (dropped) as necessary to change the total requirements. A billet changed to a different tour shifts the burden of manpower to a new position. Added (dropped) tours increase (decrease) the manpower load in only those tours so changed. As can readily be seen a change over all ship types is much more effective on seatour opportunities than a change on only one ship type.

The other variable in officer requirements is the number of ships that are available for manning. While this variable is more often a constraint on the manpower analyst, its importance must not be overlooked. The projection of the

number of ships is made for succeeding fiscal years. Depending on the trend of acquisition and disposal of hardware, manpower requirements will vary according to the number of billets per ship type. If the total number of ships is decreasing, but the ships with the highest billet requirements is increasing, the requirements for manpower may increase. The model can be used to give the analyst a feel for the magnitude of the effects on manpower required in a changing hardware environment, and it can assist in planning for the manpower needs of the future.

The second consideration in billet changes is the preparation of the individual officer for further assignment. This consideration is linked to the applications to tour positions discussed below but also must be considered in billet assignments. The number of billets in a given ship type can determine the eligibility of the officers to move on to higher positions of increasing complexity. If this skill can be transferred between ship types then the billets can also be interchanged. However, if a billet is unique to a certain specific ship type, then the number of billets in the tour position below (or junior to) the unique billet must be sufficient to train officers for future assignment to that billet.

2. <u>Tour Positions Within the Professional Development Path</u>

The importance of the career development path in the management of personnel was explained in Section II. The effects of manipulation on the parameters of the path are

evident in the values of seatour opportunities. In the model the parameters of the tour position matrix are the years of service necessary to obtain a tour and the length of time in the tour. Also associated with tour assignment is the rank requirement for each tour position. Because of the nature of the submarine community the rank required in a tour is commensurate with the normal advancement of officers, so that a tour that falls within the normal zone for lieutenant commander will normally require a lieutenant commander to fill the position. Since tours normally fall in a sequence of steps with few or no alternatives there are no tours that are considered to be filled by officers with the correct number of years of service but with lower rank than is normally found in those years of service. On the other hand, if a tour position extends into a higher rank, those officers that are in either rank are included as eligible for that tour position. For example, the normal advancement from lieutenant to lieutenant commander is at nine years of service. (App. B-1) If a tour starts in year seven and goes to year ten, personnel in both ranks will be considered eligible for that tour. Even if the tour length is changed to end before the normal promotion year to the next higher rank any officer that is advanced early is still eligible for that tour position.

With the constraint on rank held constant, as discussed above, the parameters of tour start and length can be adjusted for analysis of the effect on seatour opportunities,

or new tours can be assessed as to their feasibility with respect to the existing tours. Again adjustments must be made with caution and consideration of the qualifications necessary to fill a tour (e.g., a commanding officer's tour cannot be lowered below an executive officer's tour since the first is only possible upon successful completion of the second). Formal training requirements act as constraints on how early or late a tour can begin. Above all, the requirement to safely man the ship with officers of requisite knowledge and experience must play a major role in determining what changes are possible.

All these things considered the manipulation of tour positions can proceed. An extension of tour length will make more officers available to fill a tour but may impact on other tour positions. If a tour is started earlier more manpower will be available to fill positions before some fraction leave the system. A tour that is placed later in the career development path may push a subsequent tour into later years of service and reduce its manpower supply.

In the model presented in the thesis analysis is performed only on the seatour positions. Time not spent at sea is considered open space and offers flexibility in movement of sea tours ahead or back unless they impinge on other seatours. It is realized that unconstrained movement of seatour positions may have important consequences on major shore duty tours. For this reason any shore duty which is required or preferred in an officer's career path must be

considered when performing this type of analysis. Inclusion of shore billets in the seatour position matrix is discussed in Section V.B. as an extension to the present model.

Sometimes the analyst may wish to view the effects of added tours. This may come from a completely new requirement or a separation of an old requirement into two distinct tours. When a new tour is added new billets are implicit to the analysis (in the model they are prompted explicitly). If the new tour is an extension of an old one billets can be shared, and the effect is the same as lengthening the original tour. If new billets are intended the SEATOUR calculation will enable the analyst to see if he can fulfill the commitment. In any circumstance, new billets are just another way to investigate the effect on the manpower system of changes in the professional development path.

3. Seatour opportunities - balancing officer requirements with manpower supply

The ultimate goal of the SUBTOURS computer program is to calculate the seatour opportunities or shortfalls in the submarine officer corps. A few of the applications within the program have been discussed above. However, the final result is the ratio of officer requirements to manpower supply, and the numerical value of this ratio can be important in planning changes in the manpower system. The mechanics of the calculations were discussed in Section III.A. and B.2.b., but the implications of the results can effect the planning of alternatives. In fact, this is the virtue of an inter-

active model. Even more than the actual value for each fiscal year the trend of the values is instructive in deciding which alternative to choose.

Both positive and negative values are percentages, the positive value a percentage of the manpower pool that can fill a seatour position, the negative value a percentage of positions that are unmanned. The tour position with which the ratio is related is also important. For tours early in a career (e.g., division officer) the value of seatour opportunities requires a large change in billets or personnel for a small change in value. However, in later tours it may be true that the ratio can be effected by a small increase in personnel, but to get that increase a much larger one must occur at accessions to account for the loss of personnel as they advance to the higher positions. As mentioned previously, the higher tour positions are constrained by time so that the higher the tour position the earlier the change must occur in accessions. This comes about due to the fact that manpower policy in the submarine officer community allows little or no lateral entry (i.e., officer inputs with seniority upon entry) because of the unique training of the officer corps from internal sources (Ref. 2).

Observations over a period of years prove that a change in supply will take a longer time to affect seatour opportunities than a change in requirements. Thus, the advantage of planning early in the cycle of events is demonstrated

in the application of the SUBTOURS program to manpower management applications.

B. ANALYSIS OF CURRENT SUBMARINE FORCE DATA

To demonstrate some of the applications presented in the previous section actual unclassified data of the submarine force for fiscal years 1980 through 1986 were used to compute seatour opportunities with the SUBTOURS model. The data were changed in thirteen different ways by using the model to simulate various situations that might require reevaluation of the current manpower distribution plan, and to offer a few alternatives to the present career path that could actually be considered while analyzing the present manpower system.

The computer output is contained in Appendices D and E to illustrate what a typical terminal session might look like. Appendix D contains the output and changes in the nuclear officer data, and Appendix E is the strategic weapons systems officer data output. The alternatives considered were chosen first, to display as many of the model's capabilities as possible and secondly, to present scenarios that may resemble changes with which a contemporary analyst would likely experiment. The changes are <u>not</u> actual plans of the Office of CNO (Manpower/Training OP-13), but they are offered by the author as alternatives that might realistically be considered.

Both terms that comprise the seatour opportunities ratio are considered. Parameters that affect the requirements for officer positions at sea are manipulated first. These changes

are often situations that may arise due to factors beyond the manpower manager's control. In fact, he/she may be asked to predict the possible consequences of such contemplated changes. An example of the type of situation with which he/she might be faced is presented in the Congressional Budget Office's Background Paper on the alternatives of our sea-based strategic forces, primarily alternatives to the Trident submarine (Ref. 1). The manager may be tasked with determining the alternative that can be most efficiently manned with our present resources.

The second set of parameters that deal with officer supply, namely the tour position start and length, are analyzed to attempt to create a more effective career path, one that will meet the requirements of Section II and Ref. 13.

The discussion in this section will be more meaningful if referral is made to Appendices D and E to observe the results of the computations for each change presented.

At the front of Appendices D and E is a printout of the seatour opportunities as computed from the current data. These figures should be used as a benchmark with which to compare the seatour opportunities that resulted when the current data were changed in the analyses that follow. Directly following the current seatour opportunities is a display of the current data used in the calculation. Most of the changes that follow are analyzed for the nuclear officer community since they form the bulk of the submarine population. The supply of SWS officers was derived from the POPI model

(Ref. 14) by subtracting the nuclear officer supply from the total submarine officer supply provided by Ref. 14. Though this method of SWS supply determination may be somewhat inaccurate it provides the model with at least a starting point for analysis and can be refined as a better understanding of the SWS communities makeup is determined.

The results of the seatour opportunities for both communities seem to reflect the present day statistics of manpower requirements and supply in the submarine force. The SWS community shows some erratic behavior which is probably the combined result of inaccurate data and a general shortage of SWS officers throughout that community. The requirements for nuclear trained officers compares favorably with the results of the FY-79 Officer Warfare Study (Table 4 of Ref. 15). The value of seatour opportunities for senior officers (tour five) compares exactly with the values in Ref. 16 of 36 percent.

1. Officer Requirements

a. Ship Requirements

Change I postulated that the delivery of new ships was accelerated by one ship for every year so that an additional ship was added to the inventory above the normal schedule for every year from 1981 to 1984. Ship types SSN 688 and SSBN (Trident) were selected as the two categories to demonstrate the accelerated delivery schedule.

The results indicate that the accelerated delivery schedule stabilizes the seatour opportunities over the years.

Where the original data prompted seatour opportunities to decrease in later years (easing the burden on the executive officer and commanding officer tour positions) the new ships kept the ratios approximately constant.

Change II was the opposite of change I. The schedule of deliveries was slowed by one ship each year. Additionally, ship type one, SSN 578, had some units decommissioned in 1982 and 1984. The trend in seatour opportunities this time was a decrease in later years. However, the critical year of 1982 is still far short of personnel in the executive officer position.

b. Billet Structure

Change III examines what the seatour opportunities would be if the billet structure was similar to the structure in the FY-79 Officer Warfare Study (Ref. 15), division officer billets were transferred to the department head tour. Since Ref. 15 distinguishes between Polaris/Trident and Poseidon SSBN billets the billets-ships variable was changed. (outside the model) to account for the two ship types separately. SSBN 1 is the designation for Polaris/Trident and SSBN 2 is the designation for Poseidon.

Filling the department head tour with three billets on SSN ship types results in seatour opportunities that are close to one, providing little slack in manpower distribution. At the same time, the seatour opportunities in the division officer tour are decreased indicating that the supply is more than sufficient to meet the demand for officers until 1984.

Change IV involves both nuclear and SWS officers aboard the fleet ballistic missile submarines (SSBN) and is part of both appendices. The SSBN is manned by two complete crews and as such requires normal billets of the ship manning documents (Refs. 7 through 12) to be doubled in the model. Normally, the SWS officers fill two division officer billets on both crews of an SSBN and the navigator position on one crew (the navigator tour is in the department head tour of the nuclear community). To reduce the deficit of SWS officers in the division officer and navigator tours two billets (one for each crew) in the division officer tour and one billet on Poseidon class ships from the navigator tour were transferred from the SWS model to the nuclear officer model. As might be expected, the SWS community showed very few undermanned tour positions as a result of the change. The nuclear department head tour, however, became undermanned.

Change V illustrates what the seatour opportunities would be if all SWS positions on the SSBN ship type were transferred to the nuclear community. Clearly this change and Change IV prove that more planning must be done to fill the SSBN tour position than merely shifting billets from one community to the other.

Change VI was designed to demonstrate how the analyst would handle the problem of changing the billet structure over time. Since the model does not do this automatically it must be manipulated manually. The change postulated that billets would increase in FY 1984 in the department

head tour (tour two) by one billet (except for the SSN 597 and SSN 688). The analysis is performed by comparing the original seatour opportunities for 1980 through 1983 with the seatour opportunities of the changed data for 1984 through 1986 and ignoring the years 1980-83 in this output.

The final billet change, Change VII, was computed to observe the effects of adding small numbers of billets to two differently populated tours. Two billets were added to the division officer tour (e.g., training billets) and to the major command tour. As expected, the seatour opportunities of tour one increased by only thirty percent while the major command seatour opportunities almost doubled.

2. Officer Supply

Since the model does not presently allow changes to the officer supply the only means of providing personnel to fill a billet is by manipulation of the tour position matrix. This actually simulates the manpower manager's situation who is not in a position to affect the officer supply except by such changes in tour position and length.

a. Tour Positions

Both Change VIII and Change IX were directed at eliminating the shortage of officers in the executive officer (XO) and commanding officer (CO) billets. Change VIII lengthened tour positions three and four by one year. This had the effect of eliminating the shore duty between the XO and CO tours. Change IX moved tours three and four back one and a half years earlier and eliminated the shore tour

between department head and XO. The first alteration had a greater effect at eliminating the shortages in the XO and CO tour positions. All but the last three fiscal years have positive seatour opportunities and in the last three years the shortages are significantly reduced. The added year in these tours made an additional year group of officers available for them and was significantly more effective than trying to take advantage of personnel earlier in their careers (Change IX).

Change X was a demonstration of the tour adding capability of the model, and it was also intended to show the seatour opportunities related to an earlier submarine career path of a split tour of two years apiece for the division officer. Since the division officer's total tour was lengthened to four years the department head tour (now tour three) was moved forward one year to retain the shore tour between the division officer and department head tours and the latter lengthened by one half year to account for the decrease in officer stocks due to its later position.

The results show both division officer tours to have slightly decreased seatour opportunities most likely from the increased total length of the two tours. The department head tour had increased seatour opportunities even with the added half year, most likely caused by pushing the tour past the end of an officer's initial obligation, at a time when officer stocks significantly decrease.

Change XI was an extension of the previous change and was computed with the XO and CO tour pushed later and

lengthened to retain the shore tour between the department head and XO tours. The lengthening of the XO and CO tours eliminated shore duty between these two tours. All that was achieved by this change was a decrease of the shortages in the XO and CO tours as compared to the effects of Change X.

b. Multiple Career Paths

<u>Change XII</u> is an illustration of the procedure necessary for the present model to deal with the problem of multiple career paths, which is discussed in more detail as an extension to the model in Section V. The career path that was analyzed is shown in Appendix B-2 as an alternative to the normal professional development path of a nuclear submarine officer. The XO tour is evenly divided among personnel who assume the billet directly after a department head tour and personnel who have two years of shore duty before filling an XO billet. The CO billet is accordingly adjusted to give the personnel that did not go to shore duty after the department head tour two years of shore duty between XO and CO tours. The others who had shore duty after the department head tour go on to a CO billet after finishing the XO tour. The space of nine months shown as shore duty in the career path is the required prospective commanding officer's school prior to assuming command (Ref. 13).

To accommodate the model the analyst must determine a single start time and length for the two non-coincident tours. To arrive at a reasonable estimation the start times and lengths are averaged between the two separate paths to

obtain common parameters. If the distribution of people going to separate paths are not equal, as was the case in this example, the average would be weighted by the proportion of people following each career path. The adjusted parameters used in the model are shown in Appendix B-2 by the broken lines across the seatour positions. The results of the computation show a fairly uniform distribution of personnel across all tours.

Change XIII was made with the same altered career path to eliminate the shortage of officers that remained in the CO tour position by lengthening that tour by one half year. The result was to eliminate the shortages in 1982 and 1983, but a shortage still remains in years thereafter. To eliminate the remaining shortages other analyses would have to be made.

V. LIMITATIONS AND EXTENSIONS OF THE MODEL

A. ASSUMPTIONS AND CONCURRENT LIMITATIONS

Inherent in any modeling process is a simplification of real life data so that the information can be organized in a structure suitable for calculation. This is necessary to keep the model from becoming a disorderly array of exceptions to the rules that govern the model. At the same time it must be complete enough not to be misleading. It is up to the designer to formulate assumptions that simulate reality as closely as possible yet are easily understood in the results.

Seatour opportunities form a basis for analysis of the officer professional development path. It is the ultimate goal of a manpower manager to plan a path to be followed as closely as possible by the entire community, though there will be exceptions. The computation of the ratio of demand to supply assumes that all personnel follow the career development path exactly as designed. Coincident with this assumption is the assumption that only those officers with years of service matching the tour position parameters are available to fill requirements.

If a tour position starts or ends in the middle of a specific year of service the number of officers available to serve in that tour position, with years of service equal to the year in which the tour starts (ends), is equal to the total number of officers in that year group times the fraction of a year spent in the tour position. In reality, by

the model's assumption that all officers follow the same career path, all officers in that year group are available to serve in that tour, but serve only for the fraction of the year that encompasses the tour. Of course, the value of the total officer supply available is the same in either case.

The mechanics of supply determination were outlined in Section III.B.2.b. The underlying assumption that allows us to choose only those officers with a rank at or above the normal rank in that tour position is that due to the straightforward nature of the submarine professional development path (i.e., qualifications for a tour are primarily dependent on successful completion of the previous tour) each tour is positioned at a time in an officer's career that is most advantageous to the qualifications required for that position. By accepting this assumption reorganization of tour positions is made more restrictive. For example, the commanding officer's tour cannot be moved to a time earlier than fifteen years of service (see Appendix B-1). Otherwise the model would include lieutenant commanders that were not accepted for promotion but are counted in the inventory. Similarly, a tour that gets pushed forward to a later time may pick up inventory that would not normally fill that tour.

Each tour position starts at the same time in a specific year of service for all ships in the model. Since officers' year group is linked to the fiscal year this assumes that each tour is renewed at the same time each year. But due to ships schedules and different needs it is not possible to

make each tour start and length on every ship coincident. This limitation is not considered too restrictive because on the large scale of all ships the times will average out. Also, this inaccuracy is not important to the manpower manager for planning purposes.

If two tours happen to exist side by side in the tour position matrix and have the same start and length parameters, the model will determine the total requirements for both tours and will compare that to the total supply available for the period of the tours. However, the model will not account for coincident tours with different start or length parameters. The common parameters must be determined manually outside the model. One possible remedy to this shortcoming can be found by averaging the two unequal parameters (either start or length) and weighting that average by the ratio of positions required for each tour. An example of this calculation is contained in the analysis of current supply data Section IV.B.1.c. (Changes XII and XIII).

The supply of officers in the model is obtained from an outside activity (Ref. 14) and as such is not presently subject to change. As will be explained in the following section variable changes in the supply of officers could prove to be useful in the analysis. Officer stocks are fixed in the variable SUPPLY and can only be adjusted by reassigning values to elements of the array outside the program function. Though this restraint limits the effects of a change in accession policy, the model remains accurate for

several years of analysis, since these changes are slow to impact on the final calculation of seatour opportunities. Since little or no lateral entry is assumed in manpower flow of the officer corps a change in accessions would not be felt for several years in the later (and often more critical) tour positions. It is also anticipated that an updated version of the supply of officers will continue to be made available from the same source as before.

Billets in a tour position are allocated according to ship type. When requirements are determined the value varies according to the number of ships per type over the fiscal years that are analyzed. It is assumed that the number of billets per ship type will not vary over time. While this assumption is probably valid, an analyst may want to examine the effect of changing billets over time, such as a ship with new mission requirements. This can be accomplished, but it requires the model to run for each new set of circumstances. If the number of years analyzed is large enough, the years for which the billet structure does not apply can be ignored.

Implicit with the above assumption is the limitation on the way fiscal years are handled. If some information is changed in the model it would be convenient to eliminate those years that do not apply. The model is arranged to analyze only the number of fiscal years desired but must always start with the first year of data supplied, i.e., the user must enter the model at the first fiscal year. From that point information can be analyzed for as many years as data are available.

B. EXTENSIONS FOR INCREASED SENSITIVITY

The limitations presented above are considered no hindrance to careful analyses of seatour opportunities in the submarine force, but improvement is always possible on any model to bring it closer to reality. Possible extensions are suggested to remove some of the limitations or refine the assumptions and increase the model's usefulness and versatility. However, it must be kept in mind that a model cannot grow out of bounds or it will lose the purpose for which it was originally intended.

There are three types of improvements that can be made to an interactive computer model: in the mechanics of the program that save computer and user time and effort; by a refinement of the assumptions to add realism; and by providing a broader scope to encompass a wider range of problems that enable the user to find better solutions to an integrated manpower system.

With regards to the mechanics of the SUBTOURS model there are always many cosmetic changes that can be employed to suit the user in the way the program displays and changes data, or in the quality control of input. The model could be changed to accept any fiscal year as the beginning year as long as there is data to support it. A user could then exclude years at the beginning of the data as well as the end. Also, a rearrangement of branching sequences could allow the user the choice of correcting any mistakes in the input to changes to the tour position matrix or let the program do

it automatically as it does now. The assignment of ranks required for a tour position could be made more explicit so that the officers available would be more precisely determined, rather than by the normal promotion path.

The second type of improvement is a refinement of the assumptions. The SUBTOURS model assumes that all officers enter a tour at a specific time in their years of service, and that they follow only one path. This was dealt with in Section III.B.2.b. in Changes XII and XIII (multiple career paths) but it could be refined even further. Both officer assignment variables and officer supply fluctuations (such as changes in continuation rates due to changes in tour positions) could be written into the program for further depth in analysis. For example, how will a change in accessions help fill the gaps created by new ship building or a billet structure change.

The third extension to the model can vary as widely as there are ideas for different alternative ways of managing manpower. The SUBTOURS model looks only at opportunities for assignment to sea. Also important are the positions manned ashore. While billet information is less tangible in the shore area due to the large variability in jobs and the qualifications to man them, the model could be constructed to accept these positions just the same as a position on board a ship

Equally as feasible as adding shore billets the model can be adapted to be used by all communities. This capability is

already being formulated (Ref. 5) and will provide manpower planners with consistent results between communities.

Finally, one possible use for a planning model such as this one could be in the training of manpower managers. Not only can it help the analyst understand his problem and offer solutions to them, but it would serve as a basis for understanding generally how some manpower systems work and the parameters that affect the utilization of manpower. Given a problem and a set of constraints to be followed the student can learn what changes he can make to solve the problem and gain better insight into the sensitivity of the parameters that affect manpower planning.

VI. CONCLUSIONS AND RECOMMENDATIONS

Traditionally, the job of manpower distribution has been reactive in nature. Only when a shortage of personnel was realized would action to correct the problem be taken. Now, more than ever, it is increasingly apparent that the manpower manager must plan ahead of time to be able to make adjustments before a problem makes it necessary. Planning always involves an element of forecasting the conditions that may prevail in the future and is therefore subject to inaccuracies.

Yet, with the assistance of modelling the manager can analyze different situations and prepare himself/herself for a change in requirements of manpower allocation before it takes him/her by surprise.

Of significant value in modelling is the ability to experiment with different strategies by merely changing input. It is not only inexpensive but less time consuming to manage manpower in this way. Experimentation by fluctuating the flow of actual manpower resources to billet positions and observing the results can be frustrating and inconclusive. An analysis of the results of the model can indicate trends in manpower flows and stocks. The results can also be used to prompt corrections to eminent decisions based on new information that crops up during planning.

The SUBTOURS model computer program shows how an interactive system can be designed for integration into the manpower planning process. The program was constructed with

the objective of automating a portion of the calculations that would require tedious repetition of arithmetic computations if otherwise performed manually. When the data from each ship, billet and tour position are combined to represent the force structure, the volume of information is prohibitive to performing the type of calculations that the model can easily accommodate. Thus, analysis that would otherwise be ignored due to its immensely time consuming nature, can be considered for its value in assisting the planning of manpower allocations.

In addition to the model mechanics a brief analysis of current submarine officer data was explored in order to show ways in which the model can be used as a planning tool. The accuracy of the model depends on the input information, but projections into the future are often, at best, estimates of what will eventually occur. In general, the results of the calculations must be read with the knowledge that the figures are primarily useful as indications of a trend and should not be viewed as precise predictions about the future.

As in any area of research the SUBTOURS model cannot begin to cover all aspects of manpower distribution planning. It is entirely possible that there still exist some inaccuracies in the model's ability to manipulate the data that were explored in this thesis and the model does not pretend to present a comprehensive plan of the submarine officers' professional development path. However, with the demonstration that the model does approximate realistic situations as currently evidenced in the submarine force (Section IV.B.) it is

recommended that the ideas basic to the model be investigated further for future application to manpower management problems.

Specifically it is recommended that investigation concentrate on the following areas:

1. The reliability of the model to predict with reasonable accuracy the projected manpower strengths in seatour positions.

2. Integration of shore duty billets in the model will provide a more complete and accurate picture of the requirements for manpower distribution.

3. Some of the methodology of the submarine model is likely to be valuable in other officer communities.

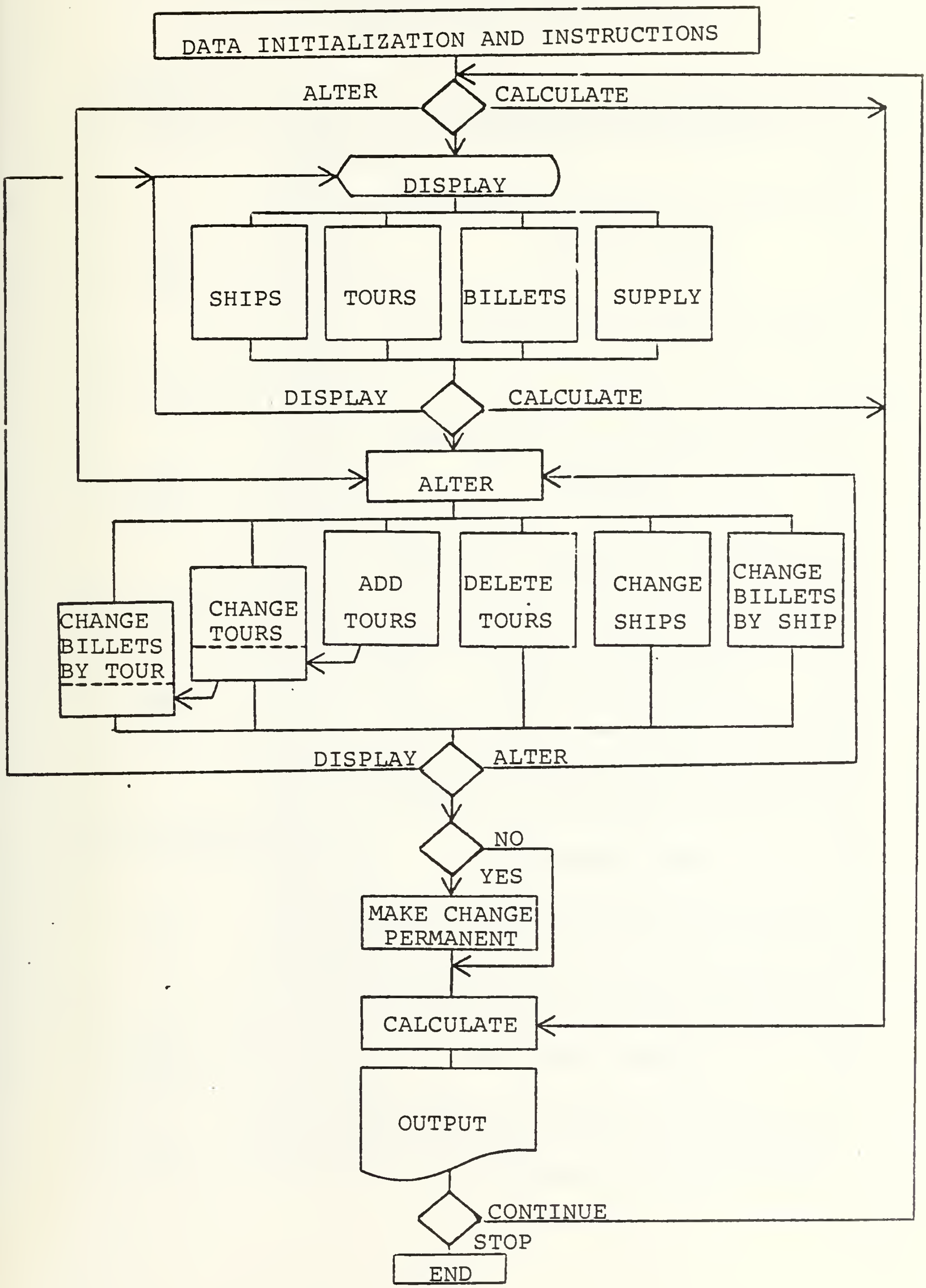
4. The ability to analyze multiple career paths will refine the sensitivity of the model to changes in manpower distribution policy.

5. An option of changing the stock of officers to account for changes in continuation rates of officers due to adjustments in tour length, increases in accession rates, or changes in the environment of the community would enhance the realism of the model and offer the analyst another parameter with which he can experiment to determine the most feasible solution to his problem.

Unquestionably, the Navy must be equipped with advanced tools to assist in the planning of manpower distribution if it is to make effective use of the manpower resources that are available. The tools cannot be so sophisticated that

managers are reluctant to use them, but they must be comprehensive enough to provide information that is useful but unavailable from another source. Manpower resources differ from hardware resources in that hardware if used ineffectively will still remain part of the Navy'a assets, though with limited productivity. Manpower resources have a tendency to leave the system if not assigned productively.

APPENDIX A - FLOW CHART



APPENDIX B-1

NUCLEAR SUBMARINE OFFICERS NORMAL SEATOUR POSITIONS

RANK	Y.O.S.	SUBMARINE SEATOURS
CAPT	28	
	27	
	26	MAJOR COMMAND
	25	
	24	
	23	
	22	
CDR	21	
	20	COMMAND
	19	
	18	
	17	
	16	
LCDR	15	
	14	EXECUTIVE OFFICER
	13	
	12	
	11	
	10	DEPARTMENT HEAD
LT	9	
	8	
	7	
	6	
	5	
LT(JG)	4	DIVISION OFFICER
	3	
ENS	2	
	1	

APPENDIX B-2

NUCLEAR SUBMARINE OFFICERS ALTERNATIVE SEATOUR POSITIONS

RANK	Y.O.S.	SUBMARINE SEATOURS	
CAPT	28		
	27		
	26		
	25	MAJOR COMMAND	
	24		
	23		
	22		
CDR	21		
	20		
	19	COMMANDING OFFICER	COMMANDING OFFICER
	18		
	17		
	16		
LCDR	15		
	14		EXECUTIVE OFFICER
	13	EXECUTIVE OFFICER	
	12		
	11		
	10		
LT	9	DEPARTMENT HEAD	
	8		
	7		
	6		
	5		
LT (JG)	4	DIVISION OFFICER	
	3		
ENS	2		
	1		

APPENDIX C

STRATEGIC WEAPONS SYSTEMS OFFICER NORMAL SUBMARINE SEATOUR POSITIONS

RANK	Y.O.S.	SUBMARINE SEATOURS
CAPT	28	
	27	
	26	
	25	
	24	
	23	
	22	
CDR	21	
	20	
	19	
	18	
	17	
	16	COMMAND SS OR ASR
LCDR	15	
	14	
	13	
	12	SSBN NAVIGATOR/XO SS OR ASR
	11	
	10	
LT	9	
	8	SSBN WEAPONS OFFICER
	7	
	6	
	5	
LT(JG)	4	
	3	SSBN DIVISION OFFICER
ENS	2	
	1	

APPENDIX D

A TYPICAL COMPUTER TERMINAL SESSION

```
                    7 SUBTOURS 1980

A MODEL FOR ANALYSIS OF THE PROFESSIONAL DEVELOPMENT PATH
             OF THE SUBMARINE OFFICER CORPS


DO YOU WISH TO SEE THE INSTRUCTIONS
                    ANSWER YES OR NO
Y


THIS PROGRAM CALCULATES SEA TOUR OPPORTUNITIES OR SHORTFALLS
IT USES FOUR(4) SETS OF DATA


     NO. OF SHIPS BY TYPE PER YEAR
     POSITION OF SEATOURS W,R TO TIME IN SERVICE
     BILLET REQUIREMENTS FOR EACH TOUR PER SHIP TYPE
     SUPPLY OF OFFICERS PER RANK AND YEARS OF SERVICE


NORMALLY THE VALUES OF THE SEATOUR OPPORTUNITY TABLE WILL SHOW
THE CHANCE OF BEING ASSIGNED TO A SEATOUR FOR OFFICERS WITH
COINCIDENT TIME IN SERVICE
IF THE VALUE IN THE TABLE IS IN PARENTHESES IT MEANS
THE TOUR IS UNDERMANNED, AND THE VALUE IS THE PERCENTAGE
BY WHICH THE TOUR IS SHORT


OFFICER SUPPLY IS CALCULATED ONLY FROM OFFICERS WITH RANK
AT OR ABOVE THE NORMAL RANK ASSOCIATED WITH EACH TOUR
HOWEVER, TOTAL SUPPLY DISPLAYED INCLUDES OFFICERS WITH
RANK LOWER THAN REQUIRED FOR CERTAIN TOURS


OPTIONS:
YOU CAN DISPLAY THE DATA,ALTER THE DATA,OR LET THE PROGRAM CALCULATE
                THE SEA TOUR OPPORTUNITIES DIRECTLY


DISPLAY DATA BY TYPING                        DISPLAY
ALTER DATA BY TYPING                          CHANGE
FOR DIRECT CALCULATION OF SEA TOURS TYPE      SEATOUR
SEATOUR
```

NORMAL SEATOUR OPPORTUNITIES FOR NUCLEAR SUBMARINE OFFICERS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	849	879	905	943	975	1007	1039
2	287	302	314	332	348	363	378
3	161	166	171	178	185	191	197
4	161	166	171	178	185	191	197
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	131	132	109	127	134	141	154
4	163	154	137	131	130	137	135
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.75	0.72	0.69	0.68	0.69	0.71	0.73
2	0.92	0.94	0.90	0.89	0.85	0.79	0.79
3	(0.19)	(0.20)	(0.36)	(0.29)	(0.28)	(0.26)	(0.22)
4	0.99	(0.07)	(0.20)	(0.26)	(0.30)	(0.28)	(0.31)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

DO YOU WISH TO CONTINUE
ANSWER YES OR NO
N

CURRENT DATA OF THE NUCLEAR SUBMARINE OFFICER COMMUNITY

```
PROJECTION OF SHIPS PER SHIP TYPE FOR 7 YEARS              ENTER 1
POSITION OF TOURS W/R TO YEARS OF SERVICE                  ENTER 2
BILLET REQUIREMENTS FOR EACH SHIP TYPE PER TOUR            ENTER 3
SUPPLY OF OFFICERS FOR NEXT 7 YEARS BY TIME IN SERVICE     ENTER 4

TYPE NUMBER OF DISPLAY DESIRED
⎕:
      1
```

		1980	1981	1982	1983	1984	1985	1986
1	SSN578	5	5	5	5	4	4	4
2	SSN585	5	5	5	5	5	5	5
3	SSN594	13	13	13	13	13	13	13
4	SSN597	1	1	1	1	1	1	1
5	SSN637	39	39	39	39	39	39	39
6	SSN688	10	15	18	23	27	31	35
7	SSBN	44	44	45	46	48	49	50
8	AS	6	6	6	6	6	6	6
9	SUBRON	7	7	7	7	7	7	7
10	AMPHIB	3	3	3	3	3	3	3
11	SERV F	2	2	2	2	2	2	2

```
DISPLAY MORE DATA?
                    ANSWER YES OR NO
Y
```

CURRENT DATA (NUCLEAR) CONT.

TOUR NUMBER	1	2	3	4	5
TOUR START	1.5	7.0	12.0	16.7	23.0
TOUR LENGTH	3.0	3.0	2.0	3.0	3.0

```
DISPLAY MORE DATA?
                    ANSWER YES OR NO
Y

SHIPS-1,TOURS-2,BILLETS-3,SUPPLY-4
TYPE NUMBER OF DISPLAY DESIRED
□:
      3
```

BILLET REQUIREMENTS

TOUR POSITIONS		1	2	3	4	5
1	SSN578	8	2	1	1	0
2	SSN585	6	2	1	1	0
3	SSN594	7	2	1	1	0
4	SSN597	3	1	1	1	0
5	SSN637	7	2	1	1	0
6	SSN688	6	3	1	1	0
7	SSBN	8	3	2	2	0
8	AS	0	0	0	0	2
9	SUBRON	0	0	0	0	2
10	AMPHIB	0	0	0	0	1
11	SERV F	0	0	0	0	1

CURRENT DATA (NUCLEAR) CONT.

SHIPS-1,TOURS-2,BILLETS-3,SUPPLY-4
TYPE NUMBER OF DISPLAY DESIRED
⎕:
4

YEARS OF SERVICE	1980	1981	1982	1983	1984	1985	1986
1	540	540	540	540	540	540	540
2	424	505	505	505	505	505	505
3	406	402	479	479	479	479	479
4	352	396	392	467	467	467	467
5	325	336	378	374	446	446	446
6	176	222	229	258	255	304	304
7	138	143	180	186	209	207	246
8	129	120	122	155	161	181	179
9	84	117	113	112	140	143	156
10	93	84	113	107	109	137	144
11	63	90	72	96	93	92	115
12	63	57	81	65	86	83	83
13	78	61	54	78	63	83	79
14	53	71	55	49	71	58	75
15	60	52	71	55	48	67	58
16	43	60	52	71	55	48	67
17	47	42	55	46	63	49	43
18	56	46	40	50	40	55	43
19	59	56	45	39	48	38	53
20	49	57	53	43	37	45	40
21	41	44	56	52	46	41	45
22	42	41	44	56	52	46	41
23	29	37	36	39	50	46	41
24	35	28	36	35	38	48	44
25	31	33	26	34	34	36	45
26	25	29	31	24	32	33	34
27	16	18	21	21	17	14	14
28	6	10	11	12	12	10	8
29	4	4	6	7	7	7	6
30	3	3	3	4	5	5	5

CHANGE I

```
THERE ARE SIX(6) MEANS OF CHANGING DATA

TO CHANGE NO. OF SHIPS BY SHIP TYPE      ENTER 1
TO CHANGE TOUR POSITION VALUES           ENTER 2
TO ADD NEW TOUR POSITIONS                ENTER 3
TO DELETE TOUR POSITIONS                 ENTER 4
TO CHANGE BILLETS BY TOUR POSITION       ENTER 5
TO CHANGE BILLETS BY SHIP TYPE           ENTER 6
WHEN YOU ARE FINISHED WITH A CHANGE      ENTER 0

ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
⎕:
      1
ENTER SHIP TYPE NUMBER
⎕:
      5
                          CURRENT DATA
             1980    1981    1982    1983    1984    1985    1986
SSN688        10      15      18      23      27      31      35

ENTER NEW DATA FOR ALL YEARS, EVEN IF REPEATED OR ZERO
⎕:
      10 16 20 26 31 35 35

DATA ENTERED AS:    10    16    20    26    31    35    35

ENTER NEXT SHIP TYPE NUMBER
⎕:
      7
                          CURRENT DATA
             1980    1981    1982    1983    1984    1985    1986
  SSBN        44      44      45      46      48      49      50

ENTER NEW DATA FOR ALL YEARS, EVEN IF REPEATED OR ZERO
⎕:
      44 45 47 49 50 50 50

DATA ENTERED AS:    44    45    47    49    50    50    50
```

CHANGE I RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	849	893	933	985	1015	1039	1039
2	287	308	326	350	366	378	378
3	161	169	177	187	193	197	197
4	161	169	177	187	193	197	197
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	131	132	109	127	134	141	154
4	163	154	137	131	130	137	135
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.75	0.73	0.71	0.71	0.71	0.73	0.73
2	0.92	0.96	0.94	0.94	0.89	0.82	0.79
3	(0.19)	(0.22)	(0.38)	(0.32)	(0.31)	(0.28)	(0.22)
4	0.99	(0.09)	(0.23)	(0.30)	(0.32)	(0.30)	(0.31)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

CHANGE II

```
                         CURRENT DATA
              1980    1981    1982    1983    1984    1985    1986
SSN578          5       5       5       5       4       4       4


ENTER NEW DATA FOR ALL YEARS, EVEN IF REPEATED OR ZERO
⎕:
      5 5 4 4 3 3 3


DATA ENTERED AS:     5     5     4     4     3     3     3


ENTER NEXT SHIP TYPE NUMBER
⎕:
      6
                         CURRENT DATA
              1980    1981    1982    1983    1984    1985    1986
SSN688         10      15      18      23      27      31      31


ENTER NEW DATA FOR ALL YEARS, EVEN IF REPEATED OR ZERO
⎕:
      10 14 16 20 23 26 29


DATA ENTERED AS:    10    14    16    20    23    26    29


ENTER NEXT SHIP TYPE NUMBER
⎕:
      7
                         CURRENT DATA
              1980    1981    1982    1983    1984    1985    1986
 SSBN          44      44      45      46      48      49      49


ENTER NEW DATA FOR ALL YEARS, EVEN IF REPEATED OR ZERO
⎕:
      44 44 45 45 46 46 47


DATA ENTERED AS:    44    44    45    45    46    46    47
```

CHANGE II RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	849	873	885	909	927	945	971
2	287	299	306	318	328	337	349
3	117	121	123	127	130	133	137
4	117	121	123	127	130	133	137
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	131	132	109	127	134	141	154
4	163	154	137	131	130	137	135
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.75	0.72	0.67	0.66	0.65	0.66	0.68
2	0.92	0.93	0.88	0.85	0.80	0.73	0.73
3	0.89	0.92	(0.11)	1.00	0.97	0.94	0.89
4	0.72	0.79	0.90	0.97	1.00	0.97	(0.01)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

DO YOU WISH TO CONTINUE
ANSWER YES OR NO

CHANGE III

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
       5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
⎕:
      5
ENTER TOUR NUMBER
⎕:
      1
CURRENT BILLETS ARE

TOUR POSITION  SSN578 SSN585 SSN594 SSN597 SSN637 SSN688 SSBN 1 SSBN 2   AS   SUBRON AMPHIB SERV F
       1           8      6      7      3      7      6      8      8     0      0      0      0

ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
⎕:
      7 6 6 3 6 6 10 8 0 0 0 0

NEW BILLETS ENTERED AS:

TOUR POSITION  SSN578 SSN585 SSN594 SSN597 SSN637 SSN688 SSBN 1 SSBN 2   AS   SUBRON AMPHIB SERV F
       1           7      6      6      3      6      6    .10      8     0      0      0      0

ENTER TOUR NUMBER
⎕:
      2
CURRENT BILLETS ARE

TOUR POSITION  SSN578 SSN585 SSN594 SSN597 SSN637 SSN688 SSBN 1 SSBN 2   AS   SUBRON AMPHIB SERV F
       2           2      2      2      1      2      3      3      3     0      0      0      0

ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
⎕:
      3 3 3 1 3 3 2 2 0 0 0 0

NEW BILLETS ENTERED AS:

TOUR POSITION  SSN578 SSN585 SSN594 SSN597 SSN637 SSN688 SSBN 1 SSBN 2   AS   SUBRON AMPHIB SERV F
       2           3      3      3      1      3      3      2      2     0      0      0      0
```

CHANGE III DATA

		1980	1981	1982	1983	1984	1985	1986
1	*SSN578*	5	5	5	5	4	4	4
2	*SSN585*	5	5	5	5	5	5	5
3	*SSN594*	13	13	13	13	13	13	13
4	*SSN597*	1	1	1	1	1	1	1
5	*SSN637*	39	39	39	39	39	39	39
6	*SSN688*	10	15	18	23	27	31	35
7	*SSBN 1*	11	11	12	13	15	16	17
8	*SSBN 2*	34	34	34	34	34	34	34
9	*AS*	6	6	6	6	6	6	6
10	*SUBRON*	7	7	7	7	7	7	7
11	*AMPHIB*	3	3	3	3	3	3	3
12	*SERV F*	2	2	2	2	2	2	2

DISPLAY MORE DATA?

ANSWER YES OR NO

Y

SHIPS-1,TOURS-2,BILLETS-3,SUPPLY-4
TYPE NUMBER OF DISPLAY DESIRED
⎕:
3

BILLET REQUIREMENTS

TOUR POSITIONS		1	2	3	4	5
1	*SSN578*	8	2	1	1	0
2	*SSN585*	6	2	1	1	0
3	*SSN594*	7	2	1	1	0
4	*SSN597*	3	1	1	1	0
5	*SSN637*	7	2	1	1	0
6	*SSN688*	6	3	1	1	0
7	*SSBN 1*	8	3	2	2	0
8	*SSBN 2*	8	3	2	2	0
9	*AS*	0	0	0	0	2
10	*SUBRON*	0	0	0	0	2
11	*AMPHIB*	0	0	0	0	1
12	*SERV F*	0	0	0	0	1

CHANGE III RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	822	852	880	920	957	991	1025
2	307	322	333	350	363	377	391
3	163	168	173	180	187	193	199
4	163	168	173	180	187	193	199
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	131	132	109	127	134	141	154
4	163	154	137	131	130	137	135
5	87	86	70	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.73	0.70	0.67	0.66	0.67	0.70	0.72
2	0.99	1.00	0.96	0.94	0.89	0.82	0.82
3	(0.20)	(0.21)	(0.37)	(0.29)	(0.28)	(0.27)	(0.23)
4	1.00	(0.08)	(0.21)	(0.27)	(0.30)	(0.29)	(0.32)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

DO YOU WISH TO CONTINUE
ANSWER YES OR NO
N

CHANGE IV

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
       5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
⎕:
      6
ENTER SHIP TYPE NUMBER
⎕:
      7
                          SSBN
                    CURRENT  BILLETS


TOUR NO        1       2       3       4       5
BILLETS        8       3       2       2       0


ENTER NEW BILLETS FOR ALL TOURS, EVEN IF REPEATED OR ZERO
⎕:
      10 4 2 2 0
                        SSBN
                    NEW  BILLETS

ENTERED AS:       10       4       2       2       0
```

CHANGE IV RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	937	967	995	1035	1071	1105	1139
2	331	346	359	378	396	412	428
3	161	166	171	178	185	191	197
4	161	166	171	178	185	191	197
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	131	132	109	127	134	141	154
4	163	154	137	131	130	137	135
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.83	0.79	0.76	0.75	0.75	0.78	0.80
2	(0.06)	(0.07)	(0.03)	(0.01)	0.97	0.89	0.89
3	(0.19)	(0.20)	(0.36)	(0.29)	(0.28)	(0.26)	(0.22)
4	0.99	(0.07)	(0.20)	(0.26)	(0.30)	(0.28)	(0.31)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
       5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
⎕:
      6
ENTER SHIP TYPE NUMBER
⎕:
      7
                           SSBN
                    CURRENT  BILLETS


TOUR NO       1       2       3       4       5
BILLETS       8       3       2       2       0


ENTER NEW BILLETS FOR ALL TOURS. EVEN IF REPEATED OR ZERO
⎕:
      12 6 2 2 0
                         SSBN
                    NEW  BILLETS

ENTERED AS:      12       6       2       2       0
```

CHANGE V RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1025	1055	1085	1127	1167	1203	1239
2	419	434	449	470	492	510	528
3	161	166	171	178	185	191	197
4	161	166	171	178	185	191	197
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	131	132	109	127	134	141	154
4	163	154	137	131	130	137	135
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.91	0.87	0.83	0.81	0.82	0.85	0.87
2	(0.26)	(0.26)	(0.22)	(0.20)	(0.17)	(0.10)	(0.09)
3	(0.19)	(0.20)	(0.36)	(0.29)	(0.28)	(0.26)	(0.22)
4	0.99	(0.07)	(0.20)	(0.26)	(0.30)	(0.28)	(0.31)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

CHANGE VI

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
        5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
⎕:
      5
ENTER TOUR NUMBER
⎕:
      2
CURRENT BILLETS ARE

TOUR POSITION  SSN578 SSN585 SSN594 SSN597 SSN637 SSN688 SSBN 1 SSBN 2   AS   SUBRON AMPHIB SERV F
       2          2      2      2      1      2      3      3      3      0      0      0       0

ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
⎕:
      3 3 3 1 3 3 4 4 0 0 0 0

NEW BILLETS ENTERED AS:

TOUR POSITION  SSN578 SSN585 SSN594 SSN597 SSN637 SSN688 SSBN 1 SSBN 2   AS   SUBRON AMPHIB SERV F
       2          3      3      3      1      3      3      4      4      0      0      0       0

ENTER TOUR NUMBER
⎕:
      0
```

CHANGE VI RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	897	927	953	991	1023	1055	1055
2	417	432	445	464	481	497	497
3	123	128	132	138	143	148	148
4	123	128	132	138	143	148	148
5	23	23	23	23	23	23	23

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	131	132	109	127	134	141	154
4	163	154	137	131	130	137	135
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.79	0.76	0.73	0.72	0.72	0.74	0.74
2	(0.23)	(0.26)	(0.22)	(0.1[illegible])	(0.15)	(0.07)	(0.04)
3	0.94	0.97	(0.17)	(0.08)	(0.06)	(0.05)	0.96
4	0.75	0.83	0.96	(0.05)	(0.09)	(0.07)	(0.09)
5	0.26	0.27	0.29	0.35	0.37	0.33	0.32

DO YOU WISH TO CONTINUE
ANSWER YES OR NO

N

IGNORE

CHANGE VII

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
        5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
⎕:
      5
ENTER TOUR NUMBER
⎕:
      1


CURRENT BILLETS ARE

TOUR NO    SSN578 SSN585 SSN594 SSN597 SSN637 SSN688   SSBN    AS    SUBRON AMPHIB SERV F
   1          8      6      7      3      7      6       8      0       0      0      0


ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
⎕:
      9 8 9 4 9 8 12 0 0 0 0

NEW BILLETS ENTERED AS:

TOUR NO    SSN578 SSN585 SSN594 SSN597 SSN637 SSN688   SSBN    AS    SUBRON AMPHIB SERV F
   1          9      8      9      4      9      8      12      0       0      0      0


ENTER TOUR NUMBER
⎕:
      5


CURRENT BILLETS ARE

TOUR NO    SSN578 SSN585 SSN594 SSN597 SSN637 SSN688   SSBN    AS    SUBRON AMPHIB SERV F
   5          0      0      0      0      0      0       0      2       2      1      1


ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
⎕:
      0 0 0 0 0 0 0 4 4 1 1

NEW BILLETS ENTERED AS:

TOUR NO    SSN578 SSN585 SSN594 SSN597 SSN637 SSN688   SSBN    AS    SUBRON AMPHIB SERV F
   5          0      0      0      0      0      0       0      4       4      1      1
```

CHANGE VII RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1165	1205	1241	1293	1340	1384	1428
2	287	302	314	332	348	363	378
3	161	166	171	178	185	191	197
4	161	166	171	178	185	191	197
5	57	57	57	57	57	57	57

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	131	132	109	127	134	141	154
4	163	154	137	131	130	137	135
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	(0.03)	0.99	0.95	0.93	0.94	0.97	1.00
2	0.92	0.94	0.90	0.89	0.85	0.79	0.79
3	(0.19)	(0.20)	(0.36)	(0.29)	(0.28)	(0.26)	(0.22)
4	0.99	(0.07)	(0.20)	(0.26)	(0.30)	(0.28)	(0.31)
5	0.66	0.66	0.73	0.86	0.92	0.81	0.78

DO YOU WISH TO CONTINUE
ANSWER YES OR NO
Y

CHANGE VIII

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
        5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
□:
      2


YOUR CURRENT TOUR POSITION MATRIX IS:
TOUR NUMBER    1      2      3      4      5

TOUR START     1.5    7.0    12.0   16.7   23.0
TOUR LENGTH    3.0    3.0    2.0    3.0    3.0


ENTER TOUR NUMBER TO BE CHANGED
□:
      3


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER    3
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
□:
      12 3


YOUR VALUES ENTERED AS:
TOUR NUMBER     START     LENGTH
     3            12         3



ENTER TOUR NUMBER TO BE CHANGED
□:
      4


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER    4
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
□:
      16.7 4


YOUR VALUES ENTERED AS:
TOUR NUMBER     START     LENGTH
     4            16.7       4
```

CHANGE VIII RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	849	879	905	943	975	1007	1039
2	287	302	314	332	348	363	378
3	161	166	171	178	185	191	197
4	161	166	171	178	185	191	197
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	191	184	180	182	182	208	212
4	207	202	192	181	174	180	179
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.75	0.72	0.69	0.68	0.69	0.71	0.73
2	0.92	0.94	0.90	0.89	0.85	0.79	0.79
3	0.84	0.90	0.95	0.98	(0.02)	0.92	0.93
4	0.78	0.82	0.89	0.99	(0.06)	(0.06)	(0.09)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

CHANGE IX

```
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
⎕:
      2


YOUR CURRENT TOUR POSITION MATRIX IS:
TOUR NUMBER     1      2      3      4      5

TOUR START     1.5    7.0   12.0   16.7   23.0
TOUR LENGTH    3.0    3.0    2.0    3.0    3.0


ENTER TOUR NUMBER TO BE CHANGED
⎕:
      3


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER     3
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
⎕:
      10.5 2


YOUR VALUES ENTERED AS:
TOUR NUMBER      START      LENGTH
     3             10.5          2



ENTER TOUR NUMBER TO BE CHANGED
⎕:
      4


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER     4
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
⎕:
      15 3


YOUR VALUES ENTERED AS:
TOUR NUMBER      START      LENGTH
     4             15          3
```

CHANGE IX RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	849	879	905	943	975	1007	1039
2	287	302	314	332	348	363	378
3	161	166	171	178	185	191	197
4	161	166	171	178	185	191	197
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	134	133	144	152	164	171	180
4	141	135	130	145	137	135	132
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.75	0.72	0.69	0.68	0.69	0.71	0.73
2	0.92	0.94	0.90	0.89	0.85	0.79	0.79
3	(0.17)	(0.20)	(0.16)	(0.15)	(0.11)	(0.11)	(0.09)
4	(0.12)	(0.19)	(0.24)	(0.19)	(0.26)	(0.29)	(0.33)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

DO YOU WISH TO CONTINUE
ANSWER YES OR NO
Y

CHANGE X

```
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
□:
      3


YOUR CURRENT TOUR MATRIX IS:


TOUR NUMBER     1       2       3       4       5

TOUR START      1.5     7.0    12.0    16.7    23.0
TOUR LENGTH     3.0     3.0     2.0     3.0     3.0


ENTER CURRENT TOUR NUMBERS
      YOU WANT FOLLOWED BY NEW TOURS
IF YOU WANT TO ADD MORE THAN ONE TOUR BETWEEN ANY TWO CURRENT TOURS
JUST REPEAT THE NUMBER ENTERED AS MANY TIMES AS THE NUMBER OF TOURS
YOU WANT INSERTED
□:
      1


TOUR POSITIONS REVISED TO:


TOUR NUMBER     1       2       3       4       5       6

TOUR START      1.5             7.0    12.0    16.7    23.0
TOUR LENGTH     3.0             3.0     2.0     3.0     3.0


TOUR START AND LENGTH MUST NOW BE ADDED TO NEW TOURS



ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER     2
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
□:
      4.5 2


YOUR VALUES ENTERED AS:
TOUR NUMBER     START      LENGTH
     2            4.5         2
```

```
BILLETS MUST BE ADDED FOR NEW TOURS


CURRENT BILLETS ARE

TOUR NO    SSN578 SSN585 SSN594 SSN597 SSN637 SSN688   SSBN    AS    SUBRON AMPHIB SERV F
   2          0      0      0      0      0      0      0      0       0      0      0


ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
⎕:
      4 3 3 1 3 3 5 0 0 0
INCORRECT INPUT
ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
⎕:
      4 3 3 1 3 3 4 0 0 0 0

NEW BILLETS ENTERED AS:

TOUR NO    SSN578 SSN585 SSN594 SSN597 SSN637 SSN688   SSBN    AS    SUBRON AMPHIB SERV F
   2          4      3      3      1      3      3      4      0       0      0      0


ALTER MORE DATA?
                    ANSWER YES OR NO
Y
```

CHANGE X CONT.

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
        5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
□:
      2


YOUR CURRENT TOUR POSITION MATRIX IS:
TOUR NUMBER     1      2      3      4      5      6

TOUR START     1.5    4.5    7.0   12.0   16.7   23.0
TOUR LENGTH    3.0    2.0    3.0    2.0    3.0    3.0


ENTER TOUR NUMBER TO BE CHANGED
□:
      1


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER     1
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
□:
      1.5 2


YOUR VALUES ENTERED AS:
TOUR NUMBER     START     LENGTH
     1            1.5          2



ENTER TOUR NUMBER TO BE CHANGED
□:
      2


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER     2
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
□:
      4 2


YOUR VALUES ENTERED AS:
TOUR NUMBER     START     LENGTH
     2            4          2
```

```
ENTER TOUR NUMBER TO BE CHANGED
□:
      3


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER    3
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
□:
      8 3.5


YOUR VALUES ENTERED AS:
TOUR NUMBER      START      LENGTH
     3             8          3.5



1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
        5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
□:
      5
ENTER TOUR NUMBER
□:
      1


CURRENT BILLETS ARE

TOUR NO   SSN578 SSN585 SSN594 SSN597 SSN637 SSN688   SSBN   AS   SUBRON AMPHIB SERV F
   1         8      6      7      3      7      6      8      0      0      0      0


ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
□:
      4 3 4 2 4 3 4 0 0 0 0

NEW BILLETS ENTERED AS:

TOUR NO   SSN578 SSN585 SSN594 SSN597 SSN637 SSN688   SSBN   AS   SUBRON AMPHIB SERV F
   1         4      3      4      2      4      3      4      0      0      0      0
```

CHANGE X RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	451	466	479	498	514	530	546
2	398	413	426	445	461	477	493
3	287	302	314	332	348	363	378
4	161	166	171	178	185	191	197
5	161	166	171	178	185	191	197
6	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	794	853	928	965	965	965	965
2	501	558	607	632	701	750	750
3	277	320	339	348	384	414	457
4	131	132	109	127	134	141	154
5	163	154	137	131	130	137	135
6	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.57	0.55	0.52	0.52	0.53	0.55	0.57
2	0.79	0.74	0.70	0.70	0.66	0.64	0.66
3	(0.04)	0.95	0.93	0.96	0.91	0.88	0.83
4	(0.19)	(0.20)	(0.36)	(0.29)	(0.28)	(0.26)	(0.22)
5	0.99	(0.07)	(0.20)	(0.26)	(0.30)	(0.28)	(0.31)
6	0.36	0.36	0.40	0.47	0.50	0.44	0.42

CHANGE XI

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
        5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
⎕:
      2


YOUR CURRENT TOUR POSITION MATRIX IS:
TOUR NUMBER     1      2      3      4      5      6

TOUR START     1.5    4.0    8.0   12.0   16.7   23.0
TOUR LENGTH    2.0    2.0    3.5    2.0    3.0    3.0


ENTER TOUR NUMBER TO BE CHANGED
⎕:
      4


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER    4
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
⎕:
      13.5 3


YOUR VALUES ENTERED AS:
TOUR NUMBER      START      LENGTH
     4            13.5          3



ENTER TOUR NUMBER TO BE CHANGED
⎕:
      5


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER    5
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
⎕:
      17 4


YOUR VALUES ENTERED AS:
TOUR NUMBER      START      LENGTH
     5            17          4
```

CHANGE XI RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	451	466	479	498	514	530	546
2	398	413	426	445	461	477	493
3	287	302	314	332	348	363	378
4	161	166	171	178	185	191	197
5	161	166	171	178	185	191	197
6	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	794	853	928	965	965	965	965
2	501	558	607	632	701	750	750
3	277	320	339	348	384	414	457
4	153	169	178	174	170	169	184
5	205	203	194	184	171	179	181
6	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.57	0.55	0.52	0.52	0.53	0.55	0.57
2	0.79	0.74	0.70	0.70	0.66	0.64	0.66
3	(0.04)	0.95	0.93	0.96	0.91	0.88	0.83
4	(0.05)	0.99	0.96	(0.03)	(0.08)	(0.12)	(0.07)
5	0.79	0.82	0.88	0.97	(0.08)	(0.06)	(0.08)
6	0.36	0.36	0.40	0.47	0.50	0.44	0.42

DO YOU WISH TO CONTINUE
ANSWER YES OR NO
N

CHANGE XII

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
        5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
⎕:
      2


YOUR CURRENT TOUR POSITION MATRIX IS:
TOUR NUMBER     1       2       3       4       5

TOUR START      1.5     7.0     12.0    16.7    23.0
TOUR LENGTH     3.0     3.0     2.0     3.0     3.0


ENTER TOUR NUMBER TO BE CHANGED
⎕:
      3


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER     3
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
⎕:
      11 2.75


YOUR VALUES ENTERED AS:
TOUR NUMBER      START      LENGTH
     3             11          2.75



ENTER TOUR NUMBER TO BE CHANGED
⎕:
      4


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER     4
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
⎕:
      16.5 3.5


YOUR VALUES ENTERED AS:
TOUR NUMBER      START      LENGTH
     4             16.5         3.5
```

CHANGE XII RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	849	879	905	943	975	1007	1039
2	287	302	314	332	348	363	378
3	161	166	171	178	185	191	197
4	161	166	171	178	185	191	197
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	181	171	176	180	202	210	218
4	187	179	163	153	153	160	155
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.75	0.72	0.69	0.68	0.69	0.71	0.73
2	0.92	0.94	0.90	0.89	0.85	0.79	0.79
3	0.89	0.97	0.97	0.99	0.91	0.91	0.90
4	0.86	0.93	(0.05)	(0.14)	(0.18)	(0.16)	(0.21)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

DO YOU WISH TO CONTINUE
ANSWER YES OR NO
Y

CHANGE XIII

```
YOUR CURRENT TOUR POSITION MATRIX IS:
TOUR NUMBER     1       2       3       4       5

TOUR START      1.5     7.0    12.0    16.7    23.0
TOUR LENGTH     3.0     3.0     2.0     3.0     3.0


ENTER TOUR NUMBER TO BE CHANGED
⎕:
      3


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER     3
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
⎕:
      11 2.75


YOUR VALUES ENTERED AS:
TOUR NUMBER      START      LENGTH
     3             11          2.75



ENTER TOUR NUMBER TO BE CHANGED
⎕:
      4


ENTER NEW VALUES FOR TOUR START AND LENGTH
          FOR TOUR NUMBER     4
BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS
⎕:
      16.5  4


YOUR VALUES ENTERED AS:
TOUR NUMBER      START      LENGTH
     4             16.5        4
```

CHANGE XIII

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	849	879	905	943	975	1007	1039
2	287	302	314	332	348	363	378
3	161	166	171	178	185	191	197
4	161	166	171	178	185	191	197
5	31	31	31	31	31	31	31

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	1133	1219	1313	1386	1422	1422	1422
2	311	321	348	374	409	461	479
3	181	171	176	180	202	210	218
4	208	201	191	179	176	180	178
5	87	86	78	66	62	70	73

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	0.75	0.72	0.69	0.68	0.69	0.71	0.73
2	0.92	0.94	0.90	0.89	0.85	0.79	0.79
3	0.89	0.97	0.97	0.99	0.91	0.91	0.90
4	0.78	0.83	0.90	1.00	(0.05)	(0.06)	(0.10)
5	0.36	0.36	0.40	0.47	0.50	0.44	0.42

DO YOU WISH TO CONTINUE
ANSWER YES OR NO
N

APPENDIX E

NORMAL SEATOUR OPPORTUNITIES FOR STRATEGIC WEAPONS SYSTEMS OFFICERS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	180	180	184	188	196	200	204
2	90	90	92	94	98	100	102
3	55	55	56	57	59	60	61
4	10	10	10	10	10	10	10

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	76	107	133	133	133	133	133
2	96	95	113	114	95	80	95
3	70	30	44	68	35	32	37
4	21	42	42	4C	55	25	35

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	(0.58)	(0.41)	(0.28)	(0.29)	(0.32)	(0.33)	(0.35)
2	0.94	0.95	0.82	0.83	(0.03)	(0.20)	(0.07)
3	0.79	(0.46)	(0.21)	0.84	(0.41)	(0.47)	(0.39)
4	0.48	0.24	0.24	0.21	0.18	0.40	0.29

DO YOU WISH TO CONTINUE
ANSWER YES OR NO
Y

CURRENT DATA OF THE

STRATEGIC WEAPONS SYSTEMS

OFFICER COMMUNITY

```
PROJECTION OF SHIPS PER SHIP TYPE FOR 7 YEARS           ENTER 1
POSITION OF TOURS W/R TO YEARS OF SERVICE               ENTER 2
BILLET REQUIREMENTS FOR EACH SHIP TYPE PER TOUR         ENTER 3
SUPPLY OF OFFICERS FOR NEXT 7 YEARS BY TIME IN SERVICE  ENTER 4

TYPE NUMBER OF DISPLAY DESIRED
⎕:
      1
```

		1980	1981	1982	1983	1984	1985	1986
1	SBN598	5	5	5	5	5	5	5
2	SBN608	5	5	5	5	5	5	5
3	SBN616	22	22	22	22	22	22	22
4	SBN640	12	12	12	12	12	12	12
5	SBN726	1	1	2	3	5	6	7
6	SS 555	1	1	1	1	1	1	1
7	SS 563	3	3	3	3	3	3	3
8	SS 574	2	2	2	2	2	2	2
9	SS 576	1	1	1	1	1	1	1
10	SS 580	3	3	3	3	3	3	3

```
DISPLAY MORE DATA?
                  ANSWER YES OR NO
Y
```

CURRENT DATA (SWS) CONT.

```
TOUR NUMBER      1       2       3       4

TOUR START      0.7     5.5    10.3    14.0
TOUR LENGTH     2.3     2.5     1.8     2.0



DISPLAY MORE DATA?
                        ANSWER YES OR NO
Y


SHIPS-1,TOURS-2,BILLETS-3,SUPPLY-4
TYPE NUMBER OF DISPLAY DESIRED
⎕:
       3

                        BILLET REQUIREMENTS


TOUR POSITIONS     1       2       3       4

   1  SBN598       4       2       1       0
   2  SBN608       4       2       1       0
   3  SBN616       4       2       1       0
   4  SBN640       4       2       1       0
   5  SBN726       4       2       1       0
   6  SS 555       0       0       1       1
   7  SS 563       0       0       1       1
   8  SS 574       0       0       1       1
   9  SS 576       0       0       1       1
  10  SS 580       0       0       1       1
```

CURRENT DATA (SWS) CONT.

SHIPS-1,TOURS-2,BILLETS-3,SUPPLY-4
TYPE NUMBER OF DISPLAY DESIRED
⎕:
4

YEARS OF SERVICE	1980	1981	1982	1983	1984	1985	1986
1	50	50	50	50	50	50	50
2	37	69	69	69	69	69	69
3	24	23	49	49	49	49	49
4	76	25	24	50	50	50	50
5	57	73	24	23	47	47	47
6	42	49	61	27	26	45	45
7	33	38	45	55	28	26	43
8	42	32	37	45	54	31	29
9	79	40	29	34	43	53	31
10	5	70	37	28	31	38	42
11	38	1	59	28	20	24	28
12	41	29	0	47	20	14	16
13	19	37	26	0	43	18	13
14	25	15	32	23	0	37	16
15	58	72	56	74	82	74	93
16	2	5	8	3	8	6	0
17	9	23	19	37	21	24	21
18	15	10	26	25	44	30	31
19	29	13	9	25	24	43	29
20	42	24	12	7	22	22	40
21	21	31	17	22	20	34	34
22	37	43	47	28	15	6	7
23	59	36	28	22	16	16	9
24	36	29	19	20	14	9	9
25	29	34	29	20	18	14	9
26	25	24	25	25	16	11	10
27	13	16	20	18	24	25	21
28	11	9	8	6	9	0	3
29	14	5	4	4	3	5	0
30	4	8	2	2	2	1	2

CHANGE IV RESULTS

REQUIREMENTS FOR OFFICERS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	103	103	106	109	115	118	121
2	90	90	92	94	98	100	102
3	21	21	22	23	25	26	27
4	10	10	10	10	10	10	10

OFFICERS AVAILABLE

TOUR	1980	1981	1982	1983	1984	1985	1986
1	76	107	133	133	133	133	133
2	96	95	113	114	95	80	95
3	70	30	44	68	35	32	37
4	21	42	42	48	55	25	35

NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR
PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED

SEATOUR OPPORTUNITIES OR SHORTFALLS

TOUR	1980	1981	1982	1983	1984	1985	1986
1	(0.26)	0.96	0.80	0.82	0.86	0.89	0.91
2	0.94	0.95	0.82	0.83	(0.03)	(0.20)	(0.07)
3	0.30	0.71	0.50	0.34	0.71	0.81	0.73
4	0.48	0.24	0.24	0.21	0.18	0.40	0.29

DO YOU WISH TO CONTINUE
ANSWER YES OR NO
N

CHANGE IV

```
1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS
        5-BILLETS BY TOUR / 6-BILLETS BY SHIP
ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE
□:
      5
ENTER TOUR NUMBER
□:
      :1


CURRENT BILLETS ARE

TOUR NO    SBN598 SBN608 SBN616 SBN640 SBN726 SS 555 SS 563 SS 574 SS 576 SS 580
   1          4      4      4      4      4      0      0      0      0      0


ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
□:
      2 2 2 3 3 0 0 0 0 0

NEW BILLETS ENTERED AS:

TOUR NO    SBN598 SBN608 SBN616 SBN640 SBN726 SS 555 SS 563 SS 574 SS 576 SS 580
   1          2      2      2      3      3      0      0      0      0      0


ENTER TOUR NUMBER
□:
      3


CURRENT BILLETS ARE

TOUR NO    SBN598 SBN608 SBN616 SBN640 SBN726 SS 555 SS 563 SS 574 SS 576 SS 580
   3          1      1      1      1      1      1      1      1      1      1


ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE
BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO
□:
      1 1 0 0 1 1 1 1 1 1

NEW BILLETS ENTERED AS:

TOUR NO    SBN598 SBN608 SBN616 SBN640 SBN726 SS 555 SS 563 SS 574 SS 576 SS 580
   3          1      1      0      0      1      1      1      1      1      1
```

COMPUTER PROGRAM

```
                    ∇SUBTOURS[⎕]∇

     ∇ Y SUBTOURS YEAR;BRANCH;CHOICE;B;C;D;E;I;J;N;M;R;S;Z;BB;NN;RR;XX;ZZ;BD;AA
[1]     J←0
[2]    START:ZZ←SHIPS
[3]     BD←TOURS
[4]     AA←BILLETS
[5]     R←(⍴ZZ),⍴TSUPPLY
[6]     →(Y≤R[2]⌊R[4])⍴PASS
[7]     'YOU HAVE REQUESTED SEATOUR OPPORTUNITIES FOR TOO MANY YEARS FOLLOWING START DATE'
[8]     'THERE IS NOT ENOUGH DATA IN THIS WORKSPACE TO SUPPORT THE CALCULATIONS'
[9]     →0
[10]   PASS:ZZ←((Y⍴1),(R[2]-Y)⍴0)/ZZ
[11]    R←(⍴ZZ)[1]
[12]    S←(⍴BD)[2]
[13]    N←⌈+/ 2 ¯1 ↑BD
[14]    M←1↑⍴TSUPPLY
[15]    →(N>M)⍴E1
[16]    →((⍴AA)[2]≠(⍴BD)[2])⍴E1
[17]    A←SHP
[18]    LF
[19]    →J⍴LO
[20]    'A MODEL FOR ANALYSIS OF THE PROFESSIONAL DEVELOPMENT PATH'
[21]    '              OF THE SUBMARINE OFFICER CORPS'
[22]    LF
[23]    →(~ANS 'DO YOU WISH TO SEE THE INSTRUCTIONS')⍴LO
[24]    'THIS PROGRAM CALCULATES SEA TOUR OPPORTUNITIES OR SHORTFALLS'
[25]    'IT USES FOUR(4) SETS OF DATA'
[26]    LF
[27]    '      NO. OF SHIPS BY TYPE PER YEAR'
[28]    '      POSITION OF SEATOURS W/R TO TIME IN SERVICE'
[29]    '      BILLET REQUIREMENTS FOR EACH TOUR PER SHIP TYPE'
[30]    '      SUPPLY OF OFFICERS PER RANK AND YEARS OF SERVICE'
[31]    LF
[32]    'NORMALLY THE VALUES OF THE SEATOUR OPPORTUNITY TABLE WILL SHOW'
[33]    'THE CHANCE OF BEING ASSIGNED TO A SEATOUR FOR OFFICERS WITH'
[34]    'COINCIDENT TIME IN SERVICE'
[35]    'IF THE VALUE IN THE TABLE IS IN PARENTHESES IT MEANS'
[36]    'THE TOUR IS UNDERMANNED, AND THE VALUE IS THE PERCENTAGE'
[37]    'BY WHICH THE TOUR IS SHORT'
[38]    LF
[39]    'OFFICER SUPPLY IS CALCULATED ONLY FROM OFFICERS WITH RANK'
[40]    'AT OR ABOVE THE NORMAL RANK ASSOCIATED WITH EACH TOUR'
```

```
                                ∇SUBTOURS[⎕41]∇

[41]  'HOWEVER, TOTAL SUPPLY DISPLAYED INCLUDES OFFICERS WITH'
[42]  'RANK LOWER THAN REQUIRED FOR CERTAIN TOURS'
[43]  LF
[44]  'OPTIONS:'
[45]  'YOU CAN DISPLAY THE DATA,ALTER THE DATA,OR LET THE PROGRAM CALCULATE'
[46]  '                THE SEA TOUR OPPORTUNITIES DIRECTLY'
[47]  LF
[48] L0:'DISPLAY DATA BY TYPING                          DISPLAY'
[49]  'ALTER DATA BY TYPING                           CHANGE'
[50]  'FOR DIRECT CALCULATION OF SEA TOURS TYPE       SEATOUR'
[51]  BRANCH← 3 7 ρ'DISPLAYCHANGECSEATOUR'
[52]  →(+/B←,BRANCH∧.=CHOICE← 7 1 ρCHOICE←⍞)ρL1
[53]  'INCORRECT INPUT'
[54]  LF
[55]  →L0
[56] L1:→B/L2,L3,L4
[57] L2:DISPLAY 0
[58]  →(ANS 'ALTER ANY DATA?')ρL3
[59]  →L4
[60] L3:ALTER
[61]  →(~ANS 'DO YOU WANT ALL CHANGES MADE PERMANENT?')ρQUIT
[62]  I←Y-(ρSHIPS)[2]
[63]  SHIPS←ZZ,(((ρSHIPS)[1]),I)↑SHIPS
[64]  TOURS←BD
[65]  BILLETS←AA
[66] QUIT:LF
[67]  →(ANS 'DISPLAY ANY DATA?')ρL2
[68] L4:→(∨/C←(2≠ρρBD),(2≠ρρZZ),(2≠ρρAA),(3≠ρρSUPPLY))ρERROR
[69]  D←(+/BD)∘.-¯1↓0,⍳N
[70]  E←(-BD[1;])∘.+⍳N
[71]  D←1⌊D×D>0
[72]  E←1⌊E×E>0
[73]  BB←D⌊E
[74]  XX←INVENTORY BB
[75]  NN←(⍉AA)+.×ZZ
[76]  Z←XX=0
[77]  RR←(~Z)×NN÷XX+Z
[78]  RR←(RR×RR≤1)+¯1+÷(~RR>1)+RR×RR>1
[79]  RR←RR+0=RR←(⌊0.5+RR×100)÷100
[80]  LF
```

```
                    ∇SUBTOURS[⎕81]∇

[81]  'REQUIREMENTS FOR OFFICERS'
[82]  ''
[83]  '2X,12I10' FMT(¯1+YEAR+⍳Y)
[84]  'TOUR'
[85]  'I3,I9,12I10' FMT(((S,1)⍴⍳S),NN)
[86]  LF
[87]  'OFFICERS AVAILABLE'
[88]  ''
[89]  '2X,12I10' FMT(¯1+YEAR+⍳Y)
[90]  'TOUR'
[91]  'I3,I9,12I10' FMT(((S,1)⍴⍳S),XX)
[92]  LF
[93]  'NORMAL OUTPUT - OFFICERS CHANCE OF AN ASSIGNMENT TO A SEATOUR'
[94]  'PARENTHETICAL OUTPUT - PERCENTAGE TOUR IS UNDERMANNED'
[95]  LF
[96]  'SEATOUR OPPORTUNITIES OR SHORTFALLS'
[97]  ''
[98]  '2X,12I10' FMT(¯1+YEAR+⍳Y)
[99]  'TOUR'
[100] 'I3,12M⎕(⎕N⎕)⎕F10.2' ΔFMT(((S,1)⍴⍳S),RR)
[101] LF
[102] J←1
[103] →(ANS 'DO YOU WISH TO CONTINUE')⍴START
[104] →0
[105]ERROR:→C/(E1,E2,E3,E4)
[106]E1:'ERROR IN TOUR POSITION MATRIX'
[107] →0
[108]E2:'ERROR IN SHIP PROJECTION MATRIX'
[109] →0
[110]E3:'ERROR IN BILLET MATRIX'
[111] →0
[112]E4:'ERROR IN SUPPLY MATRIX'


                    ∇INVENTORY[⎕]∇

    ∇ XX←INVENTORY BB;SUP;V;I
[1]     SUP←(6,N,Y)↑SUPPLY
[2]     V←+/BD[1;]∘.< 2 4 9 15 21 30
[3]     XX←(S,Y)⍴1
[4]     I←1
[5]    LOOP:XX[I;]←BB[I;]+.×+⌿SUP[(⍳V[I]);;]
[6]     →(S≥I←I+1)⍴LOOP
[7]     →0
    ∇
```

```
                    ∇DISPLAY[⎕]∇

    ∇ DISPLAY GO;B;C;DISP
[1]    →GOρL1
[2]    LF
[3]    'PROJECTION OF SHIPS PER SHIP TYPE FOR ';Y;' YEARS                ENTER 1'
[4]    'POSITION OF TOURS W/R TO YEARS OF SERVICE                    ENTER 2'
[5]    'BILLET REQUIREMENTS FOR EACH SHIP TYPE PER TOUR              ENTER 3'
[6]    'SUPPLY OF OFFICERS FOR NEXT ';Y;' YEARS BY TIME IN SERVICE       ENTER 4'
[7]    LF
[8]    →SKIP
[9]   TYPE:'SHIPS-1,TOURS-2,BILLETS-3,SUPPLY-4'
[10]  SKIP:'TYPE NUMBER OF DISPLAY DESIRED'
[11]  CHECK:DISP←1↑|DISP←,⎕
[12]   LF
[13]   →(∨/DISP=⍳4)ρL0
[14]   'INCORRECT INPUT'
[15]   →CHECK
[16]  L0:→(1,L1,L2,L3)[DISP]×⍳DISP>1
[17]   '14X,10I6' FMT(¯1+YEAR+⍳Y)
[18]   ''
[19]   'I4,X2,A7  ,12I6' FMT(((R,1)ρ⍳R),ZZ)
[20]   →DECISION
[21]  L1:A← 2 11 ρ'TOUR START TOUR LENGTH'
[22]   '⎕TOUR NUMBER⎕,I5,10I7' FMT(⍳S)
[23]   ''
[24]   'A11 ,11BF7.1' FMT(BD)
[25]   A←SHP
[26]   →(GO=1)ρ0
[27]   LF
[28]   →DECISION
[29]  L2:(20ρ' '),'BILLET REQUIREMENTS'
[30]   LF
[31]   '⎕TOUR POSITIONS⎕,I4,20I6' FMT(⍳S)
[32]   ''
[33]   'I4,X2,A6 ,12I6' FMT(((R,1)ρ⍳R),AA)
[34]   →DECISION
[35]  L3:C← 2 8 ρ'YEARS OFSERVICE '
[36]   '8X,10I6' FMT(¯1+YEAR+⍳Y)
[37]   C
[38]   'I4,I10,10I6' FMT(((M,1)ρ⍳M),(M,Y)↑TSUPPLY)
[39]  DECISION:LF
[40]   →(ANS 'DISPLAY MORE DATA?')ρTYPE
    ∇
```

```
∇ALTER[⎕]∇

    ∇ ALTER;Y;T
[1]   LF
[2]   'THERE ARE SIX(6) MEANS OF CHANGING DATA'
[3]   LF
[4]   'TO CHANGE NO. OF SHIPS BY SHIP TYPE      ENTER 1'
[5]   'TO CHANGE TOUR POSITION VALUES           ENTER 2'
[6]   'TO ADD NEW TOUR POSITIONS                ENTER 3'
[7]   'TO DELETE TOUR POSITIONS                 ENTER 4'
[8]   'TO CHANGE BILLETS BY TOUR POSITION       ENTER 5'
[9]   'TO CHANGE BILLETS BY SHIP TYPE           ENTER 6'
[10]  'WHEN YOU ARE FINISHED WITH A CHANGE      ENTER 0'
[11]  LF
[12]  →SKIP
[13] ENTER:'1-SHIPS / 2-TOUR POSITIONS / 3-ADD TOURS / 4-DELETE TOURS'
[14]  '         5-BILLETS BY TOUR / 6-BILLETS BY SHIP'
[15] SKIP:'ENTER THE NUMBER THAT CORRESPONDS TO YOUR DESIRED CHANGE'
[16] CHECK:Y←1↑|Y←,⎕
[17]  →(∨/Y=⍳6)⍴L0
[18]  →(Y=0)⍴0
[19]  'INCORRECT INPUT'
[20]  →CHECK
[21] L0:→(1,L1,L2,L5,L3,L4)[Y]×⍳Y>1
[22]  SHIPCHG
[23]  →DECISION
[24] L1:LF
[25]  'YOUR CURRENT TOUR POSITION MATRIX IS:'
[26]  DISPLAY 1
[27] L11:LF
[28]  'ENTER TOUR NUMBER TO BE CHANGED'
[29]  →(0=T←1↑|T←,⎕)⍴DECISION
[30]  →(T≤S)⍴FUN
[31]  'INCORRECT INPUT'
[32]  →L11
[33] FUN:TOURCHG T
[34]  →L11
[35] L2:TOURADD
[36]  →DECISION
[37] L3:'ENTER TOUR NUMBER'
[38]  →(0=T←1↑|T←,⎕)⍴DECISION
[39]  →(T≤S)⍴FCN
[40]  'INCORRECT INPUT'
[41]  →L3
[42] FCN:BILLCHT T
[43]  →L3
[44] L4:BILLCHS
[45]  →DECISION
[46] L5:TOURDEL
[47] DECISION:→(ANS 'ALTER MORE DATA?')⍴ENTER
    ∇
```

```
                          ∇TOURCHG[⎕]∇

     ∇ TOURCHG T;U;V;I;J;Y;P;Q;BDI
[1]     I←1
[2]    START:U←T[I]
[3]     LF
[4]    CHECK:'ENTER NEW VALUES FOR TOUR START AND LENGTH'
[5]     '10X,⎕FOR TOUR NUMBER⎕,I5' FMT(U)
[6]     'BE SURE AND PUT A SPACE BETWEEN THE TWO NUMBERS'
[7]     →(2=ρV←,⎕)ρLO
[8]     'INCORRECT INPUT'
[9]     →CHECK
[10]   LO:BD[;U]←V
[11]    BDI←(BD[1;]≠0)/BD
[12]    →(∧/(¯1↓+⌿BDI)≤1↓BDI[1;])ρJUMP
[13]    J←1
[14]   LOOP:Y←(¯1↓+⌿BDI)⌈1↓BDI[1;]
[15]    BDI[1;]←BDI[1;1],Y
[16]    →((ρBDI)[2]>J←J+1)ρLOOP
[17]    '*****************************************************************'
[18]    LF
[19]    '                    WARNING:'
[20]    'YOUR ENTRY HAS AFFECTED ONE OR MORE OF THE OTHER TOUR POSITIONS'
[21]    LF
[22]    '*****************************************************************'
[23]    LF
[24]    BD←(BD[1;]≠0)\BDI
[25]    ' TOUR POSITIONS HAVE BEEN UPDATED TO:'
[26]    LF
[27]    DISPLAY 1
[28]    →FINISH
[29]   JUMP:LF
[30]    'YOUR VALUES ENTERED AS:'
[31]    'TOUR NUMBER     START     LENGTH'
[32]    (5ρ' ');U;(12ρ' ');BD[1;U];(9ρ' ');BD[2;U]
[33]    LF
[34]   FINISH:→(M≥N←+⌿ 2 ¯1 ↑BD)ρFINALE
[35]    Q←+/~P←(+⌿BD)≤M
[36]    N←⌈+⌿ 2 ¯1 ↑BD←P/BD
[37]    AA←P/AA
[38]    S←(ρBD)[2]
[39]    ''
[40]    'YOUR POSITION MATRIX HAS BEEN TRUNCATED BY ';Q;' POSITIONS'
[41]    'BECAUSE IT WILL NOT EVALUATE BEYOND THE DATA GIVEN IN YOUR SUPPLY MATRIX'
[42]    LF
[43]    'IF YOU WISH TO RECOVER THE LOST TOURS YOU MUST USE THE PROGRAM'
[44]    'THAT ADDS TOURS'
[45]   FINALE:→((ρT)≥I←I+1)ρSTART
     ∇
```

```
                    ∇TOURADD[⎕]∇

    ∇ TOURADD;I;J;T
[1]    LF
[2]    'YOUR CURRENT TOUR MATRIX IS:'
[3]    LF
[4]    DISPLAY 1
[5]    LF
[6]   START:'ENTER CURRENT TOUR NUMBERS'
[7]    '       YOU WANT FOLLOWED BY NEW TOURS'
[8]    'IF YOU WANT TO ADD MORE THAN ONE TOUR BETWEEN ANY TWO CURRENT TOURS'
[9]    'JUST REPEAT THE NUMBER ENTERED AS MANY TIMES AS THE NUMBER OF TOURS'
[10]   'YOU WANT INSERTED'
[11]   →(S<ρT←,⎕)ρERROR
[12]   I←1
[13]  CHECK:→(∧/T[I]≠0,⍳S)ρERROR
[14]   →((ρT)≥I←I+1)ρCHECK
[15]   J←(S+ρT)ρ1
[16]   J[T+⍳ρT]←J[T+⍳ρT]-1
[17]   S←(¯1↑ρBD←J\BD)
[18]   AA←J\AA
[19]   LF
[20]   'TOUR POSITIONS REVISED TO:'
[21]   LF
[22]   DISPLAY 1
[23]   LF
[24]   'TOUR START AND LENGTH MUST NOW BE ADDED TO NEW TOURS'
[25]   LF
[26]   TOURCHG(T+⍳ρT)
[27]   →((ρJ)=1↓ρAA)ρSKIP
[28]   →(∧/(T+⍳ρT)>1↓ρAA)ρ0
[29]   T←((T+⍳ρT)≤1↓ρAA)/T
[30]  SKIP:LF
[31]   'BILLETS MUST BE ADDED FOR NEW TOURS'
[32]   LF
[33]   BILLCHT(T+⍳ρT)
[34]   →0
[35]  ERROR:'INCORRECT INPUT   READ INSTRUCTIONS'
[36]   →START
    ∇
```

```
                              ∇TOURDEL[⎕]∇

    ∇ TOURDEL;I;J;T
[1]    'YOUR CURRENT TOUR MATRIX IS:'
[2]    LF
[3]    DISPLAY 1
[4]    LF
[5]   START:'ENTER TOUR NUMBERS YOU WANT DELETED'
[6]    'BE SURE AND PUT A SPACE BETWEEN NUMBERS IF YOU ENTER MORE THAN ONE'
[7]    →(S<ρT←,⎕)ρERROR
[8]    I←1
[9]   CHECK:→(∧/T[I]≠0,⍳S)ρERROR
[10]   →((ρT)≥I←I+1)ρCHECK
[11]   J←Sρ1
[12]   J[T]←J[T]-1
[13]   S←¯1↑ρBD←J/BD
[14]   AA←J/AA
[15]   LF
[16]   'TOUR POSITIONS HAVE BEEN UPDATED TO'
[17]   LF
[18]   DISPLAY 1
[19]   LF
[20]   (⍕'BILLETS FOR TOURS '),(⍕T),⍕' HAVE BEEN DELETED'
[21]   →0
[22]  ERROR:'INCORRECT INPUT     READ INSTRUCTIONS'
[23]   →START
    ∇
```

```
                    ∇BILLCHS[⎕]∇

    ∇ BILLCHS;T;V
[1]  START:'ENTER SHIP TYPE NUMBER'
[2]   →(0=T←1↑|T←,⎕)ρ0
[3]   →(T≤R)ρL0
[4]   'INCORRECT INPUT'
[5]   →START
[6]  L0:(25ρ' '),,SHP[T;]
[7]   (20ρ' '),'CURRENT  BILLETS'
[8]   LF
[9]   '⍞TOUR NO⍞,20I8' FMT(ιS)
[10]  '⍞BILLETS⍞,20I8' FMT(AA[T;])
[11]  LF
[12] L1:'ENTER NEW BILLETS FOR ALL TOURS, EVEN IF REPEATED OR ZERO'
[13]  →(S=ρV←,⎕)ρL2
[14]  'INCORRECT INPUT'
[15]  →L1
[16] L2:AA[T;]←V
[17]  (23ρ' '),,SHP[T;]
[18]  (20ρ' '),'NEW  BILLETS'
[19]  ''
[20]  '⍞ENTERED AS:⍞,20I8' FMT(AA[T;])
[21]  LF
[22]  →START
    ∇

                    ∇BILLCHT[⎕]∇

    ∇ BILLCHT TO;I;Y;V;LSHIPS
[1]   I←1
[2]  START:Y←TO[I]
[3]   'CURRENT BILLETS ARE'
[4]   ''
[5]   ⎕←'TOUR POSITION   ',LSHIPS←,SHP
[6]   'I8,8X ,I3,10I7' FMT(Y,AA[;Y])
[7]   LF
[8]  CHECK:'ENTER THE CHANGE IN NO OF BILLETS ASSIGNED TO EACH SHIP TYPE'
[9]   'BE SURE AND TYPE A NUMBER FOR ALL SHIP TYPES EVEN IF REPEATED OR ZERO'
[10]  →(R=ρV←,⎕)ρL0
[11]  'INCORRECT INPUT'
[12]  →CHECK
[13] L0:AA[;Y]←V
[14]  ''
[15]  'NEW BILLETS ENTERED AS:'
[16]  ''
[17]  'TOUR POSITION   ',LSHIPS
[18]  'I8,8X,I3,10I7' FMT(Y,AA[;Y])
[19]  LF
[20]  →((ρTO)≥I←I+1)ρSTART
    ∇
```

```
                    ∇SHIPCHG[⎕]∇

    ∇ SHIPCHG;T;V
[1]   'ENTER SHIP TYPE NUMBER'
[2]  START:→(0=T←1↑|T←,⎕)ρ0
[3]   →(T≤R)ρL0
[4]   'INCORRECT INPUT'
[5]   →START
[6]  L0:(20ρ' '),'CURRENT DATA'
[7]   '8X,10I8' FMT(¯1+YEAR+⍳Y̲)
[8]   A̲←SHP[T;]
[9]   'A7 ,10I8' FMT(ZZ[T;])
[10]  A̲←SHP
[11]  LF
[12] L1:'ENTER NEW DATA FOR ALL YEARS. EVEN IF REPEATED OR ZERO'
[13]  →(Y̲=ρV←,⎕)ρL2
[14]  'INCORRECT INPUT'
[15]  →L1
[16] L2:ZZ[T;]←V
[17]  LF
[18]  '⍞DATA ENTERED AS:⍞,10I6' FMT(ZZ[T;])
[19]  LF
[20]  'ENTER NEXT SHIP TYPE NUMBER'
[21]  →START
    ∇


                    ∇ANS[⎕]∇

    ∇ Y←ANS QUEST;B;ANSWER
[1]  L1:QUEST
[2]   (20ρ' '),'ANSWER YES OR NO'
[3]   →(0≠ρANSWER←⍞)ρL2
[4]   'YOU MUST ANSWER'
[5]   →L1
[6]  L2:Y←∨/'Y'=ANSWER
[7]   LF
    ∇
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